POWER PLANT ENGINEERING

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Contents of this Issue

	Page
Modernizing Old Boiler Plant in New England Textile Mill Effects 31 Per Cent Saving	784
Graphic Solution of Combustion Problems. By Oscar Knabner	789
Benson Boiler Five-Stage Evaporator	791
Diesel Engine Cylinder Lubrication. By Arthur M. Tode	792
Safety in the Ice Plant	795
The Power Behind New York	796
Comparison of Natural Gas Fuels—V. By Palmer B. Place	803
Control of Electrical Equipment in Industrial Plants—III. By E. H. Stivender	805
A. S. T. M. Holds Annual Meeting at Chicago	807
A Vacuum Tube Voltage Regulator. By L. C. Verman and L. A. Richards	808
Six Kaplan Units Develop 255,000 Hp. at Safe Harbor	810
Pneumatic Cleaning for Power and Industrial Plants. By Fred W. Lieberg	812
Rubber Belt Durability	814
Planer Drive by Two Motors. By James F. Hobart	815
Letters Direct from the Plant: Sand Blast for Cleaning Soot from Boiler Tubes. Repairing Ammonia Systems. Band Welded on Exhaust Pipe. Quick Freezing for Pipe Repairs. Exciters Reversing Their Polarity	816
Questions and Answers: Steaming of Logs. Centrifugal Pump Operation. Allowable Boiler Pressures	818
Editorial Comment: Power Rates. X-Ray Examination. Electrically Grown Vegetables	820
Off Duty	821
Weightograph for Beam Scales	822
New pH Equipment	822
Unit Cooler and Liquid Level Controller	823
New Firebrick Announced by the B. & W. Co	823
Three-Element Feedwater Control	824
Boiler Blowoff Hydrometer	824
Adjustable Speed Control	825
Leak-Proof Vertical Worm Reducer	825
Potentiometer Pyrometer	826
New Electric Hoist	826
Gift to the Engineering Foundation	827
News Notes	827
Books and Catalogs	828

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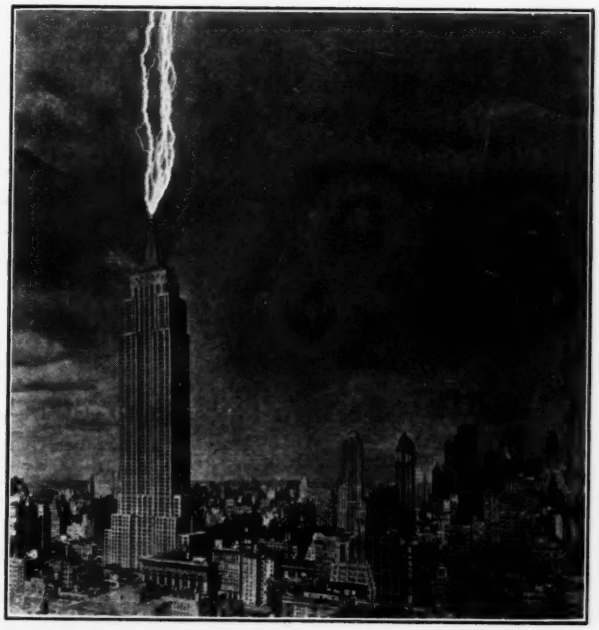
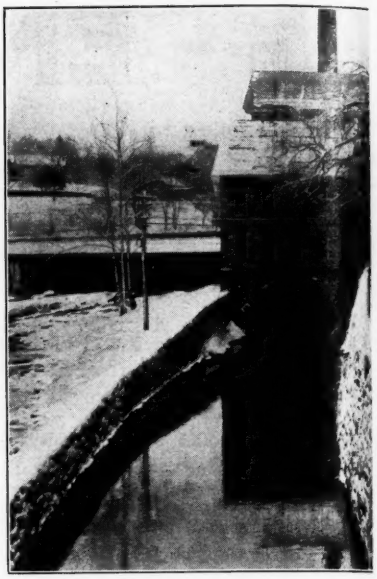


Lightning Strikes Empire State

EXTRA, EXTREE,—Great Excitement. Empire State Building Struck by Lightning! Indeed, here is a picture of the world's tallest building in the act of being struck, caught by our staff photographer just as he was on his way to a place up on 38th St. We assume it was a business engagement, but that's beside the point—he is a bright lad, this photographer of ours; quick as lightning, as is evident from the photograph. As a matter of fact, he has only one major fault and that is that he is inclined to handle the truth a bit carelessly at times. Take this picture for instance. We received it in good faith, accepting it at face value for what it was. Imagine our surprise, however, when we learned that it was not a picture of New York at all, nor of a real lightningbolt. It is only a model of New York in miniature at the Pittsfield high voltage laboratory of the General Electric Co. used in experiments to establish the protection offered by the Empire State Building to surrounding structures from direct strokes of lightning. Experiments with 5,000,000-v. bolts of artificial lightning and this model of New York's skyline show that the world's tallest structure affords protection from lightning to all buildings within a considerable radius. Bolt after bolt was hurled earthward and each time the pinnacle of the Empire State Building was struck. No damage was done, however, since the model was well grounded, just as is the original building.

Modernizing Old Boiler Plant in New England Textile Mill Effects 31 Per cent Saving



Replacement of two old hand fired boiler plants by a single pulverized coal fired plant at the Willimantic Mills of the American Thread Co. has resulted in higher fuel economy as well as reduced labor charges.

AT WILLIMANTIC, CONNECTICUT, there is located one of the mills of the American Thread Co. This particular plant is an excellent example of a typical old time New England textile mill with many stone-walled buildings draped easily and picturesquely over rolling grounds, divided by a flowing stream and the tail races of water wheels. It is an old plant, dating back to the height of New England's fame and prosperity as a textile center, and direct mechanical drive is still utilized in some of the buildings. Many others, however, have been modernized and, in these, the mechanical drives have been replaced by group and individual electric motor drives.

Until a few years ago, this plant was served by two separate boiler houses. These supplied steam and power to two separated mills. There were engine rooms in both mills, and the power from the engines was transmitted to the mill machinery by the usual heavy belt transmission system. At the so-called No. 4 mill, there was and still is in operation a 1700-hp. Hewes and Phillips, twin tandem compound Corliss engine, while at No. 2 mill, there is installed an 800-hp. engine of the same make.

Both of these engine rooms have been retained in much their original condition and are still in operation, although steam turbines have been added in recent years to carry the new electrical load.

In addition to the engines and turbines, electric power is also obtained from a 500-kw. remote controlled hydroelectric plant and a certain amount of direct hyraulic (mechanical) power is available.

Several years ago, the company started work on the replacement of the two separate boiler plants by a single central boiler plant of modern design. The two old plants were approximately 1500 ft. apart. In one, there were installed four horizontal, hand fired water tube boilers of 250 hp. each, three of which were Aultman and Taylor units and one, a B. & W. unit. These boilers had been in operation about 40 yr.; in fact, the B. and W. unit bears the serial number 57. It is of interest to know that these boilers were in operation until about a year and a half ago when they were finally shut down. The working pressure, in the meantime, had been decreased to 125 lb. from 150 lb., the pressure for which they were made originally.

The other plant consisted of 14 hand fired Manning vertical boilers each rated at approximately 200 hp. The combined operating force required by these two boiler plants consisted of 11 firemen and two coal and ash handlers. By means of the rehabilitation to be described, this force has now been reduced to a total of four men, —one fireman on each watch (8 hr. shifts) and one general utility man who is on duty during the mill running time only.

While the old boilers were always maintained in the best operating condition, and, although their economy was reasonably good, the equipment was rapidly approaching the end of its field of usefulness, and, about 3 yr. ago, it became quite evident that something would have to be done to modernize the steam plants.

Rather than spend more money in an attempt to prolong the life of the old equipment, it was decided that any new capital invested in the plant should be used for something more permanent. Plans were made, therefore, to replace the 14 Manning boilers in Plant No. 2 with modern boilers, and to shut down entirely Plant No. 4.

Equipment Installed in the New Plant

The equipment selected for the replacement consists of three 657-hp., 225-lb. per sq. in., Union Iron Works, Type N boilers with front radiant heat elements, rear water walls, and air-cooled side walls and floors; Foster superheaters; three 6000 lb. per hr. Aero unit pulverizers; a 150-ton Jeffrey bunker and coal handling system; complete new high pressure steam header; feedwater piping; pumping and heating equipment; and a

1500-ft. run of 7-in. welded joint steam line to deliver steam from the new boilers to the site of the old horizontal boilers in No. 4 Mill.

These three boilers were installed one by one in the building which contained the 14 Manning units, without any interference with normal operation of the mills.

Work was started for the first unit in the summer of 1928 when three of the Manning boilers could be removed for its accommodation, and the entire job was completed in the fall of 1929, all removal of old equipment, preparation of foundation for new, and changeover of the feedwater system being done by the mill engineering department, while the new equipment was installed by the manufacturers.

As may be noted from the accompanying drawings of the old and the new plants, the new boilers are served by the old stack of the Manning boiler plant. This stack is constructed of radial brick, is 175 ft. high and has an inside diameter of 9 ft. Because of the low draft loss design of the new boilers, even with this comparatively small stack and using natural draft for the secondary air supply, it has been found possible to deliver 105,000 lb. of steam per hour with only two boilers in service.

Air Supply and Combustion Control

Fans in the unit pulverizers induce the draft necessary for circulation of the air through the air-cooled Detrick walls and floor passages of the boilers. The path of this circulation is downward from the top of the sidewalls, under the furnace floor to a duct on the front to rear center line of each boiler and under the boiler room floor in a well insulated metal duct to the pulverizer.

At the pulverizer, this air can be controlled so as to go directly to the primary air fan or be directed through the full length of the pulverizer for drying wet coal. In practice, the temperature of the preheated air varies from 175 deg. F. at low rating to 285 deg. F. at high rating with a fairly clean furnace floor. The efficacy of this method of cooling is well attested by the condition of the furnace floors and the side wall surfaces. In the first unit installed, which has now been in service two years, and which frequently was called upon to operate at 300 per cent rating before the second unit was in place, the side walls are covered with a thin coating of lightly adhering ash which is never disturbed and, under which, the face of the brick presents, even now, the same appearance as when new.

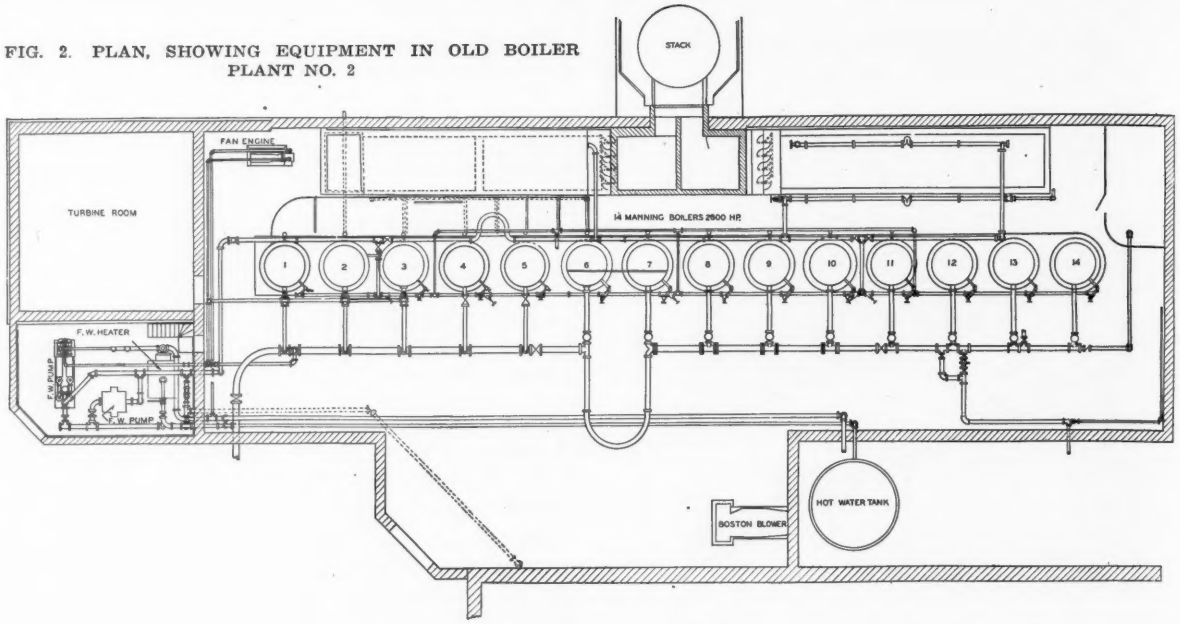
Each pulverizer is fed from the overhead coal bunker by two spouts which combine to cover one third of the total bunker capacity. This feature reduces to a minimum the necessity of replenishing the bunker supply over the week ends.

Feeding of the fuel is manual, controlled at each

IN THE NEW BOILER ROOM AT THE AMERICAN THREAD CO.

This view of the firing aisle shows the burners of the three pulverized coal fired boilers. The unit pulverizers are located at the right.

FIG. 2. PLAN, SHOWING EQUIPMENT IN OLD BOILER PLANT NO. 2



pulverizer by a combination of raising or lowering the coal feed sleeve for wide variation in steam demand, and by manipulation of a 21-speed controller on the small d.c. motor which drives the feed table. As each boiler is equipped with Bailey boiler meters, the fireman is enabled to follow accurately the steam demand with fuel feed and air control. As a check on the Bailey meters, a Ranarex CO_2 recorder is also employed. This is arranged so that it can be connected at will to any of the boilers, and any disagreements of the two types of instruments are investigated with an Orsat apparatus.

An additional convenience in operation is provided by the McNeil Liquid level gages which bring the water column indications down to the level of the other instruments. The boilers are fitted with Swartwout "S-C" feedwater regulators which accurately control the rate of feed.

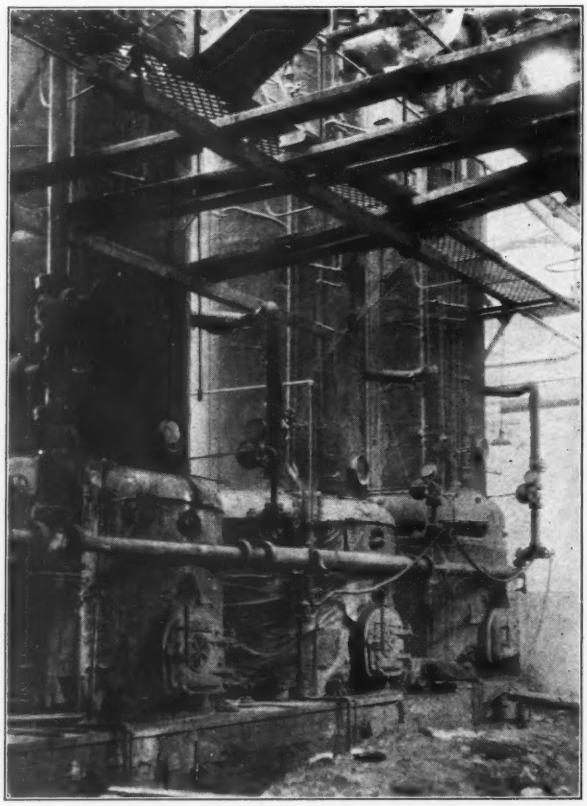


FIG. 3. FOUR OF THE OLD MANNING BOILERS, OF WHICH 14 WERE INSTALLED IN THE OLD PLANT. THESE 4 UNITS STILL REMAIN IN PLACE BUT ARE NOT USED

Boiler Feedwater Supply

Two boiler feed pumps are provided, one, a new Gould's centrifugal unit rated at 150,000 lb. per hr. driven by a 75-hp. induction motor for daytime use, and the other, a Worthington Duplex pump of the same capacity for night service.

Feedwater is heated in a 5000-hp. open Cochrane heater. Although this is an open type heater, it is used as a pressure heater, a pressure of approximately 5 lb. being maintained. Since an open heater run as a pressure heater would become air bound if no provision were made to prevent it, this heater has been vented, several calibrated orifices having been installed so as to maintain a temperature comparable to that of the pressure under which it operates.

This heater, together with the two boiler feed pumps and associated equipment, is installed in a separate room at one end of the boiler house. The heater is placed above the feed pumps so as to provide a 12-ft. static head.

Since there is at all times a considerable amount of condensate, a small centrifugal pump is provided to recirculate the water in the feedwater heater. This pump, a 100-g.p.m. unit, draws water from the bottom and returns it to the top of the heater.

A fourth small pump in the pump room is used only for furnishing water for tube cleaning.

The changes in the coal handling system have effected notable advantages: In the old boiler plant, coal

was hauled into the boiler house in small industrial dump cars and dumped on the floor in front of the boilers. The firing was done by hand.

Now, coal cars enter the boiler house on an elevated platform about 4 ft. above the boiler room floor and are dumped into a hopper which in turn delivers into a crusher. Then, by means of apron conveyors and a bucket elevator, it is delivered to the overhead storage bunker which feeds directly to the Aero pulverizers.

Four cars enter the boiler room at once and, by means of a small electric car puller, one man can spot the cars before the hopper. When this system was first placed in operation, considerable trouble was had due to dust. The entire coal handling equipment is installed in the boiler room proper and, every time a car of coal was emptied, dust was sent flying to all parts of the boiler room. To overcome this nuisance, a connection was made with the Aero pulverizers and part of the primary air is taken from a hood which covers the track hopper. This has proved an excellent solution to the problem and no further trouble has been had with dust.

With the installation of this new equipment, the boiler plant has been placed on an entirely modern basis. Of the original 14 Manning boilers, 4 still remain. While they might be used for emergency purposes, the possibility of their use is rather remote for, with only two of the new units in service, there is ample capacity to carry any normal load.

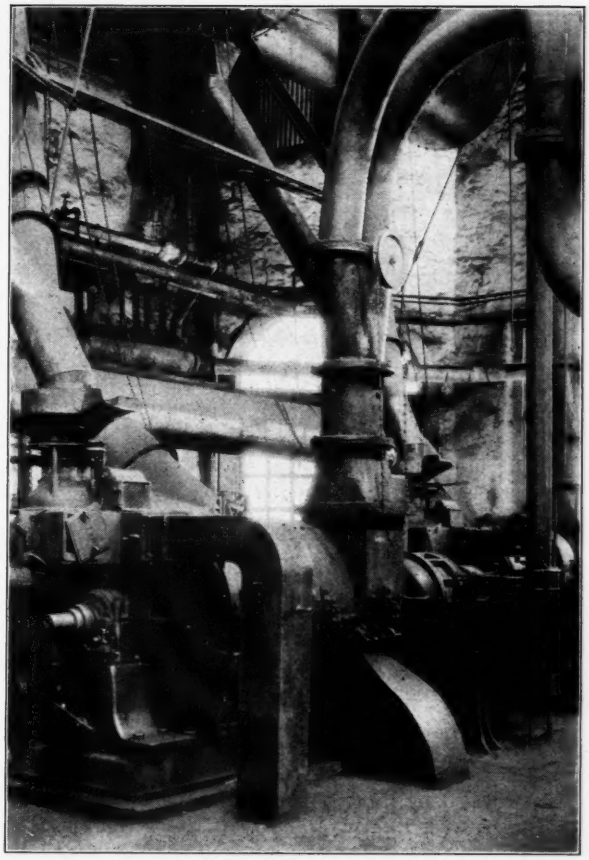


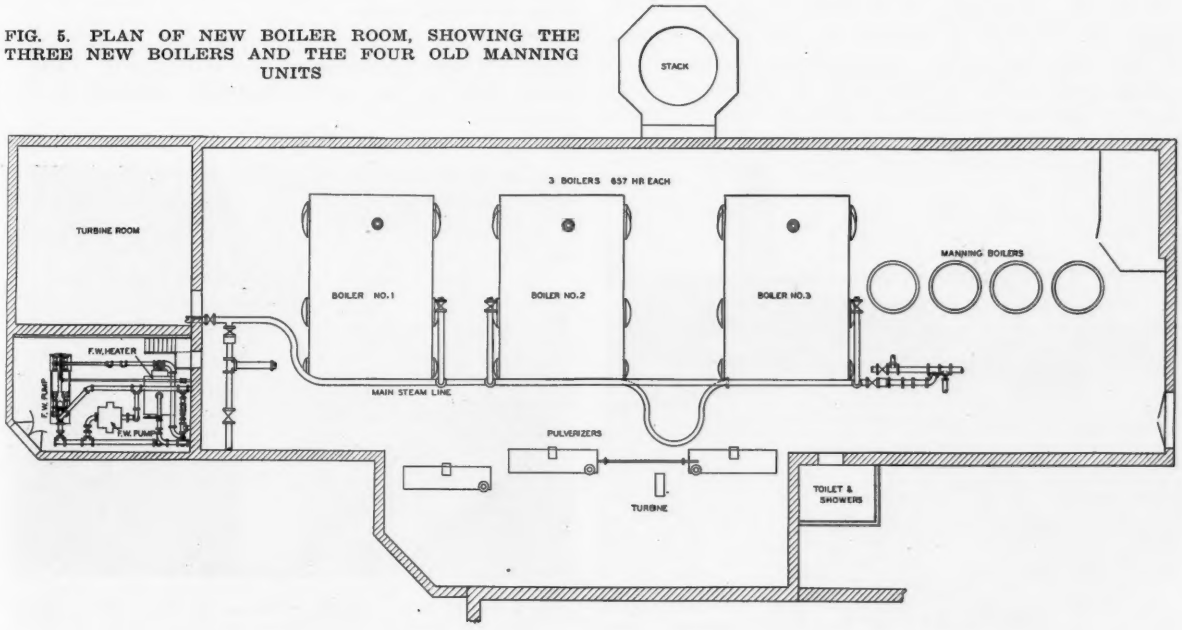
FIG. 4. THREE UNIT PULVERIZERS OF THIS TYPE SERVE THE NEW PLANT

New Steam Line

In addition to the new boiler equipment, the shutting down of the No. 4 Mill boiler plant necessitated the installation of a new high pressure steam line, not only to operate the 1700-hp. Hewes and Phillips engine installed there, but also, to furnish steam for other purposes.

This line is a 7-in. high pressure steam pipe 1500 ft. long, and was installed by the Grinnell Co. of Providence, R. I. It is of standard wrought steel throughout, with all-welded joints, and provided with long radius expansion loops. The line is suspended from steel supports and is covered with 3 in. of magnesia insulation over which is placed a one inch layer of wool felt. An outer tarred paper covering protects the line from the weather.

FIG. 5. PLAN OF NEW BOILER ROOM, SHOWING THE THREE NEW BOILERS AND THE FOUR OLD MANNING UNITS



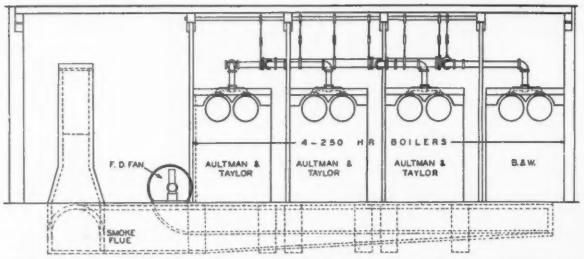


FIG. 6. AN ELEVATION OF THE FOUR OLD BOILERS IN OLD BOILER PLANT No. 4

A portion of this line is shown in the illustration at the head of this article. The small line shown directly below the steam line is a condensate return line to return condensate from No. 4 Mill to the boiler room. The amount of condensate returned is often considerable as the mill buildings have large glass exposures and in winter the heating load alone at times amounts to some 14,000 lb. of steam per hr.

A word regarding the large Hewes and Phillips Corliss engine may be of interest. This old engine is one of the few of its kind which can still be seen in operation in some of the old mills. This particular engine has been running for about 40 yr. and is still treated with loving care by the operating engineer who has grown old with it.

As a point of interest, this engine is said to have one of the largest wood rim flywheels ever built. This wheel is 28 ft. in diameter and has a 110-in. face. The rim is carried by three sets of arms, one under each of its 3 belts, with 12 arms in each set.

This is a twin, tandem, compound engine, 26 and 44 in. and 30 and 52 in., with a 60-in. stroke It is rated at 1700 hp. At present, the unit operates on 125 lb. steam pressure with superheat to give a total steam temperature of 510 deg. F. This pressure is reduced by a reducing valve from 200 lb., the pressure carried in the main steam line.

In addition to this engine and a similar smaller unit at No. 2 plant, several steam turbo generators are provided for the generation of electrical energy. A 500-kw. hydroelectric plant also feeds the electrical system. Indeed, this plant presents an excellent example of resourcefulness in the economical use of equipment. Here the most modern equipment is seen operating alongside

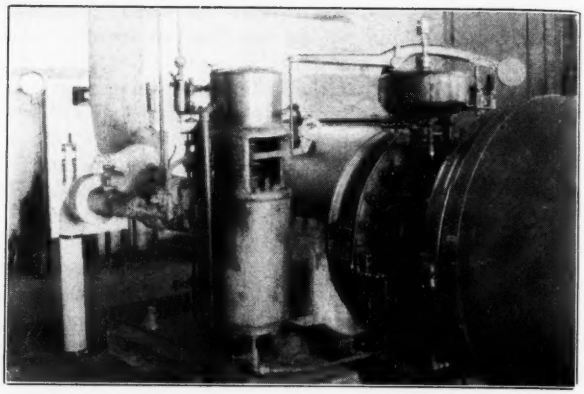


FIG. 8. ONE OF THE NEW STEAM TURBINE GENERATORS

of equipment that has been in efficient use for 40 yr. or more.

The replacement of the two old boiler plants by the single modern one has resulted in unusual economies. As previously indicated, the labor requirements of the new plant have been reduced by the installation of new equipment to a total of four men. The firemen clean one or two furnaces each night, depending upon whether two or three have been in use during the day, while the utility man disposes of the ash, looks after the coal bunker and does all general cleaning of the boiler room. In addition to the direct labor saving thus indicated, the shutting down of the old boiler plant containing four horizontal boilers relieved the demands on the time of the assistant operating engineer at that plant to such an extent that he could also take care of a portion of the mill transmission system, thus reducing costs in this direction.

Notwithstanding the fact that, due to careful operation and supervision, the two old hand-fired plants consistently gave excellent overall efficiency, the fuel efficiency of the new installation is appreciably higher and the combined labor and coal economies are showing savings of $41,000.00 per year, or 31 per cent of the previous operating costs.

The plant is under the supervision of Albert E. Welch, Master Mechanic of the Willimantic Mills, to whom credit is due for the material contained in this article.

FIG. 7. VIEW, LOOKING TOWARD OLD No. 4 BOILER HOUSE, SHOWING NEW HIGH PRESSURE STEAM LINE

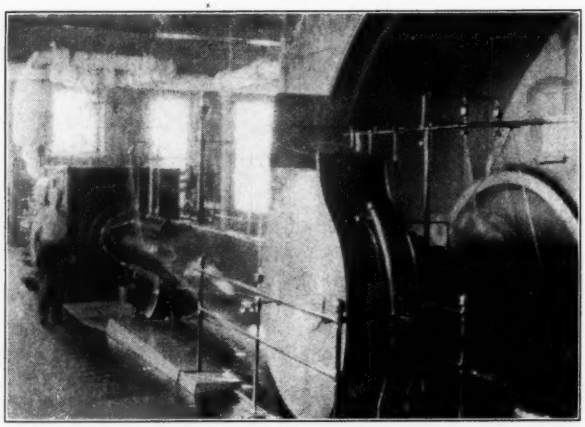


FIG. 9. THE OLD 1700-HP. HEWES & PHILLIPS CORLISS ENGINE WHICH HAS BEEN RUNNING FOR 40 YR.

Graphic Solution of Combustion Problems

PRACTICAL APPLICATION OF GERMAN RESEARCH AND EXPERIENCE IN THE FIELD OF COMBUSTION AND PULVERIZED COAL. BY OSCAR KNABER

IF A FOREIGN ENGINEER attentively follows American literature dealing for instance with combustion and pulverized fuel, he may wonder that the "practical sense" which is attributed to American engineers is so little inclined to use the results of researches and investigations of other countries. As American conditions are unknown to me, I am unable to judge about whether this is because of a certain conservatism or whether the practicing engineer does not study foreign literature.

It may therefore be of interest to point to some German investigations and results which may well be adapted to American practice.

Exact study of the combustion process, such as calculation of the heat loss in waste gases and analyses of these gases, requires knowledge of the ultimate analysis of the fuel to be burned and a considerable amount of calculating.

It is to the credit of Prof. Dr. Ing. Rosin to have pointed first to the relations between the calorific value of a fuel and the amount of air necessary for combustion as well as to their relationship with the volume of the combustion gases. Calculations for more than 100 different solid, liquid and gaseous fuels showed the surprising fact that the theoretical amount of air necessary for combustion, consequently the amount of combustion gases, bear an exact relation to the heat value regardless of the chemical composition of the fuel.

Only solid fuels may be considered here, yet liquid and gaseous fuels are subject to similar relations.[1]

CALCULATIONS BY CHART

If in a diagram the (lower) heat value of the fuel is plotted as abscissa and the theoretical amount of air necessary for combustion as ordinates, the straight line A shown in Fig. 1 results. With this line, one is able to determine immediately the amount of air for a given fuel without calculation and without knowing the ultimate analysis. Multiplying by the excess air factor, the real amount of air may be determined.

Owing to the variation of the volume with temperature and pressure, a standard condition must be assumed. As such 0 deg. C. (32 deg. F.) and 760 mm Hg (30 in. mercury) are considered in German measure. To change to other conditions, for example atmospheric pressures and temperatures, can be done with the simple formula $P_1V_1T_2 = P_2V_2T_1$ where P, V and T are pressure, volume and temperature respectively.

Figure 1 contains, furthermore, the "normal" volume of the combustion gases at different ratings of excess air. These, too, show the form of straight lines.

[1]See the book of Rosin and Fehling: "Das It-Diagramm der Verbrennung (The heat content-temperature diagram of combustion).

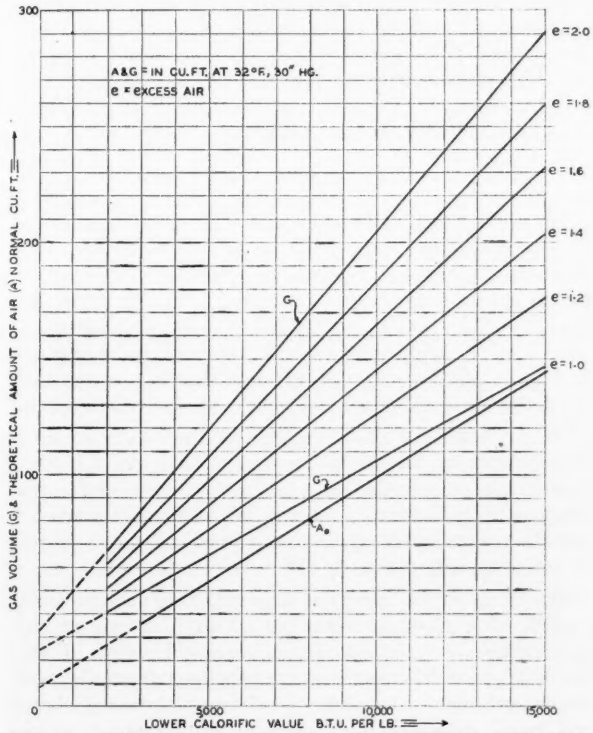


FIG. 1. VOLUME OF AIR FOR COMBUSTION AND GAS VOLUMES AS A FUNCTION OF CALORIFIC VALUE OF THE FUEL AND EXCESS AIR

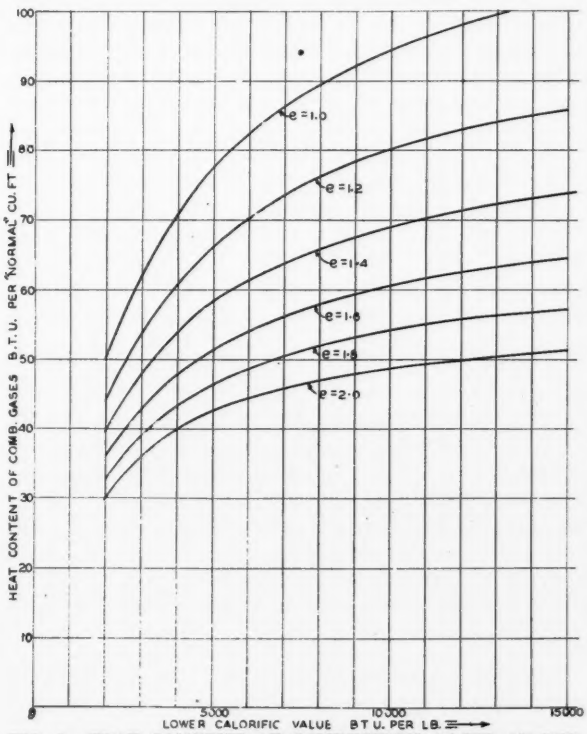


FIG. 2. HEAT CONTENT OF COMBUSTION GASES AT DIFFERENT EXCESS AIR RATIOS

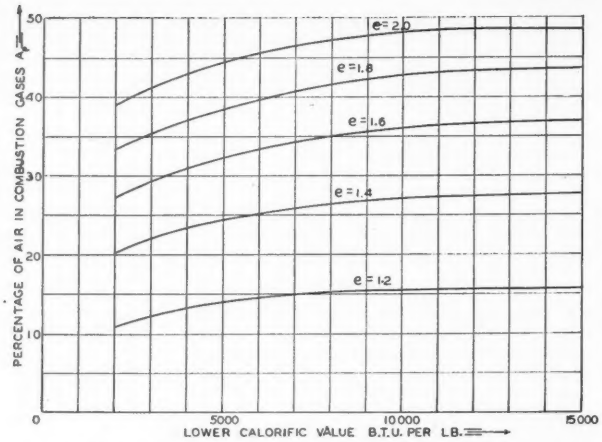


FIG. 3. PERCENTAGE OF AIR IN GASES OF COMBUSTION

To change to other than normal conditions is done as before.

Figure 2 shows the heat content of the combustion gases from fuels of different heat value and at different excess air factors. Taking now from Fig. 3 the air content of the combustion gases Ac, the theoretical temperature of combustion for a given heat value and the assumed excess air can be taken from Fig. 4 without difficulty.

Such a calculation or graphical method may be of importance if, as in metallurgical furnace practice it must be predetermined whether a certain fuel will give the required process temperature. The actual temperature will be, of course, below the calculated temperature because of the radiation which takes place in the furnace. The figure found from the chart is the theoretical maximum.

The application may be explained by an example: A coal of 13,000 B.t.u. per lb. is available and is to be burned with 1.4 excess air. From Fig. 1 theoretically 125 cu. ft. of air per lb. of fuel are required, or

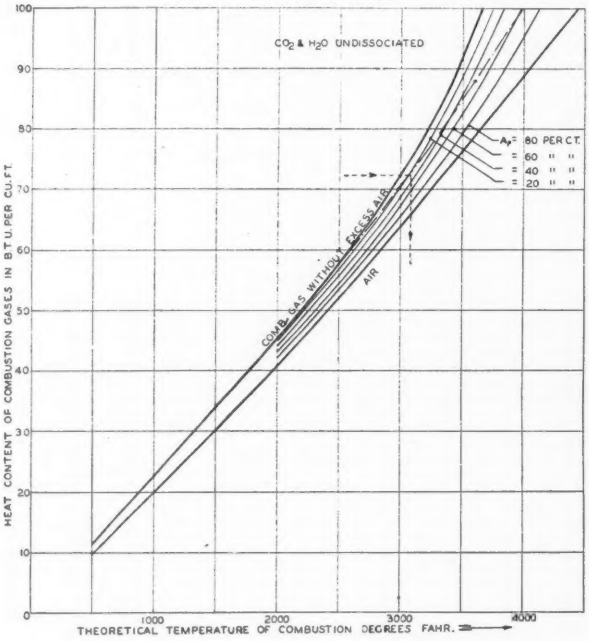


FIG. 4. THEORETICAL FLAME TEMPERATURES

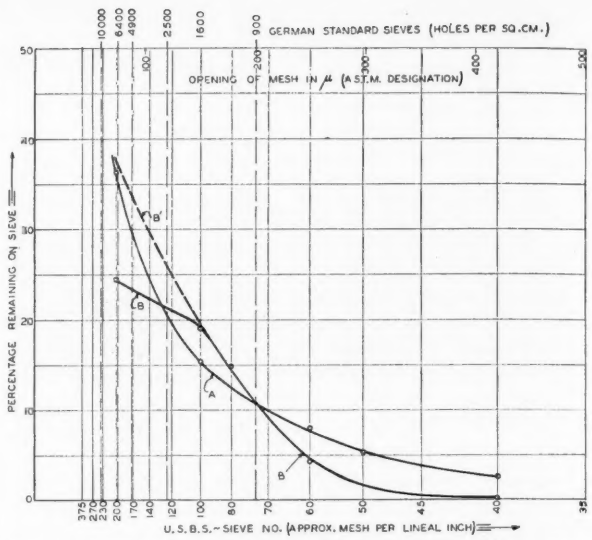


FIG. 5. APPLICATION OF CURVES FOR CHECKING SIEVE ANALYSES

actually with some excess air $1.4 \times 125 = 175$ cu. ft. The volume of the combustion gases (see G of Fig. 1) with e=1.4 is 180 cu. ft. per lb. of fuel.

Figure 2 shows that under these condition 72 B.t.u. are contained in a "normal" cubic foot of gas. Taking now from Fig. 3 the air content of the gases, 27.5 per cent, then from Fig. 4 (going along the dotted lines) the theoretical temperature is found to be 3080 deg. F. With this coal it is not possible to reach a higher furnace temperature unless the excess air is lowered.

In a similar way the heat content of the combustion gases at a known temperature may be taken from this chart. This may be of importance for determining the heat loss by waste gases. The curves in Fig. 4 are drawn up with regard to dissociation of CO_2 and H_2O but this is important only from 2600 deg. F. up.

Coal Fineness

A further reference concerns the determination of the fineness of pulverized fuel for firing purposes. For German engineers it is common practice, according to the proposition of Prof. Dr. Rosin, to characterize the fineness of a dust or pulverized coal by its characteristic line ("Kennlinie"). This procedure seems to be almost unknown to American engineers, in spite of the valuable conclusions that may be derived from it.

If, in a system of ordinates, the abscissa represents the opening of the meshes and the ordinate the total percentage of remainder on the respective sieve, the fineness of pulverized coal (or other dusty materials) can be reproduced by its characteristic line which shows a smooth curve.

In Fig. 5 the abscissa shows the sieve apertures (width of meshes) in fractions of an inch and at the same time the numbers of the standard sieves of the A.S.T.M., and (for translating purposes from German literature) on the top line the German standard sieves and mesh openings in μ (=0.001 mm.) are marked.

Two examples may explain the application of characterizing the fineness and show the conclusions drawn

from it. In the N.E.L.A.—Report "Pulverized Fuel" from Dec., 1929, is the following sieve analyses:

SAMPLE A.

On 40 mesh sieve	2.6%	Total.....	2.6%
On 50 passing 40 mesh.....	2.7%	Total on 50.....	5.3%
On 60 passing 50 mesh.....	2.7%	Total on 60.....	8.0%
On 100 passing 60 mesh.....	7.4%	Total on 100.....15.4%	
On 200 passing 100 mesh.....20.9%		Total on 200.....36.3%	

SAMPLE B.

Through 40 mesh sieve.....99.9%		Total on 40.....	0.1%
Through 60 mesh sieve.....95.7%		Total on 60.....	4.3%
Through 80 mesh sieve.....85.1%		Total on 80.....14.9%	
Through 100 mesh sieve.....80.9%		Total on 100.....19.1%	
Through 200 mesh sieve.....75.6%		Total on 200.....24.4%	

Plotting these values, it is possible to guess at a glance that curve B is not correct and that the 200 mesh sieve was damaged and that too much of the coarser material went through. The real remainder on this sieve should have been approximately 37 per cent as shown by the dotted line B.

Advantages of such diagrammatical drawing up are as follows: A faulty sieve analysis may instantly be recognized by the unsteady course of the curve. Errors of an intermediate sieve may be eliminated graphically. These errors may arise from incorrect screening. Too short a time, especially for fine sieves, gives an excessive remainder and a sudden steep inclination of the curve indicates damaged sieve (see curve B).

At all events, the graphical reproduction which may easily be done, offers a quick and especially reliable survey of the correctness of the sieve analysis. At a unsteady course of the curve screening may be done anew. If the same curve results, a damage screen is probably the cause and this may be verified by a microscopical examination.

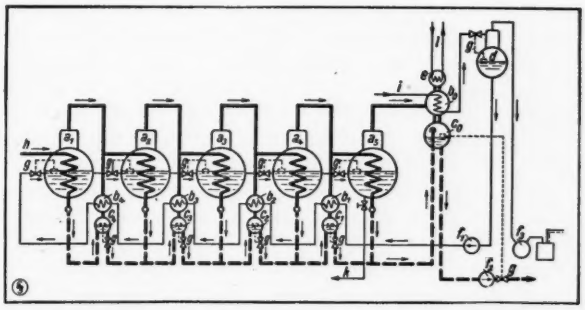
Benson Boiler Five-Stage Evaporator

DETAILS OF 5-STAGE EVAPORATOR TO SUPPLY MAKE-UP TO SIEMENS-SCHUCKERT INSTALLATION

IN THE ORIGINAL Benson boiler installation in the Gartenfeld works of the Siemens-Schuckert Corp. zeolite softened water was used as make-up.[1] A large part of the high pressure steam condensate was not recovered because considerable was used for direct heating of various kinds of apparatus and that condensate recovered was in many cases impure. Extension to the installation of another Benson[1] boiler of 90,000 to 100,000 lb. per hr. made it desirable to create a separate closed system for the Benson plant. Considering later extensions, the make-up supplied in the Benson circuit was estimated as 20,000 lb. per hr., sufficient to make an evaporator plant with a low steam consumption a necessity. With the existing layout,[2] it was impossible to make use of waste heat and it was finally decided to install one of the newly designed five-stage Atlas evaporator plants, using an initial steam pressure of about 128 lb. abs.

Diagrammatic arrangement of this five-stage evaporator plant is shown by the illustration. Raw water, in coming from the zeolite softener, is heated to about 198 deg. F. in the preheater b_0. The feed of the deaerator d is controlled by a float g and a partial vacuum, created by the vacuum pump f_3, causes the fresh water to be effectively deaerated. The boiler feed pump f_1 pumps the deaerated feed to a series of preheaters b_1 to b_4, in which the water is heated by steps up to a temperature of about 302 deg. F. All the evaporator feed enters the first evaporator effect a_1 and flows through to the following effects a_2 to a_5. With this series connection all concentrates collect in the last stage a_5 leaving this the only one to be washed out or blown down.

Evaporator a_1 is heated with live steam h, all other stages a_2 to a_5 use only vapors from the preceding stage. Part of the vapors of each stage condenses in the feed or preheaters b_0 to b_4 which together with the drain from the evaporator coils flows into the flash tanks c_4 to c_0 in which the pressure is the same as in the heating coils of the succeeding evaporator. Flashed



DIAGRAMMATIC ARRANGEMENT OF THE FIVE-STAGE EVAPORATOR PLANT

steam from these tanks c_4 to c_0 goes to the preheaters b_4 to b_0 situated above.

Series connection of the preheaters, evaporators and flash tanks ensures the maximum possible condensation of the vapors within the system so that only a small part of the vapors from the last evaporator a_5 has to be condensed in the vapor condenser e. This heat is lost in the cooling water l. All the distilled water including the condensate of the live steam from evaporator a_1 is collected in the trap c_0 from which it is returned to the feedwater storage of the Benson circuit by the distilled water pump f_2 regulated by a float valve g.

Guarantees are as follows: The plant to supply 20,200 lb. per hr. of deaerated distilled water with not more than 10 mg/litre of evaporation residue from 68 deg. F zeolite treated water with a maximum consumption of 0.24 lb. of 128 lb. abs. saturated steam per pound of distillate. Tests showed the plant to have a capacity of approximately 15 per cent above the guarantee. The water surface of the 5 evaporators is 50 sq. ft. each. Data regarding the different stages are given in the accompanying tabulation. The exceedingly low value of the loading of the evaporator surface is worthy of note. This was used to prevent a carryover as the zeolite feedwater foams easily.

IT IS THOUGHT that the first heat engine actually to perform useful work on a commercial scale was Savery's "fire engine" or pump, invented in 1697. Its modern form is known as a pulsometer.

[1] See Recent Developments of the Benson Boiler, p. 612, June 1, 1930.

[2] See Steam Generation at Critical Condition, page 718, July 1, 1928.

Diesel Engine Cylinder Lubrication

Two-cycle and Four-cycle Engines, Effects of Temperature and Pressure, Proper Methods of Supplying Oil. By Arthur M. Tode, M.E.*

SUCCESSFUL Diesel engine cylinder lubrication depends on four factors: use of properly refined oil; application of sufficient, though not excessive amounts; delivery through oil ways located so that piston and rings will receive the maximum of the charge; application at exactly the right time. To secure the best results, the oil should be delivered regularly by some form of force feed lubrication that will insure a charge of sufficient volume to cover the entire cylinder wall under the swabbing action of the piston.

Whether a Diesel engine is of the four-cycle or two-cycle type makes little, if any, difference with respect to the lubricating oil best suited for their power cylinders. Since some of the lubricants in a two-cycle engine cylinder may be scraped off from the piston and rings while they are passing the scavenging and exhaust ports, the oil consumption is generally a little higher than that of a four-cycle engine of equivalent cylinder size. Too great an oil feed with two-cycle engines is frequently a contributing cause of excessive deposits in the scavenging air ports and the exhaust ports.

In the four-cycle engine the pressure on the moving parts is not always of the same intensity. Whereas it may be difficult to spread the lubricating oil uniformly over cylinder liner surfaces when the piston rings are under pressure, yet in the four-cycle type of Diesel the pressure is released during the second stroke. As a result, the oil is more readily spread over the cylinder liner and this facilitates the sliding action of the piston and rings during the subsequent strokes of the cycle.

Cylinders of two-cycle Diesels, however, are not difficult to lubricate if the design has been carefully considered. The cylinders are the only parts requiring more than usual attention from a lubricating point of view because the oil is subjected to high temperatures at more frequent intervals over each cycle and because a high velocity of the gases of combustion at the exhaust ports increases vaporization of the lubricant in this part of the cylinder. To reduce vaporization, an oil of lower volatility could be used but this probably would mean the production of a larger carbon residue.

*Technical Division, The Texas Co.

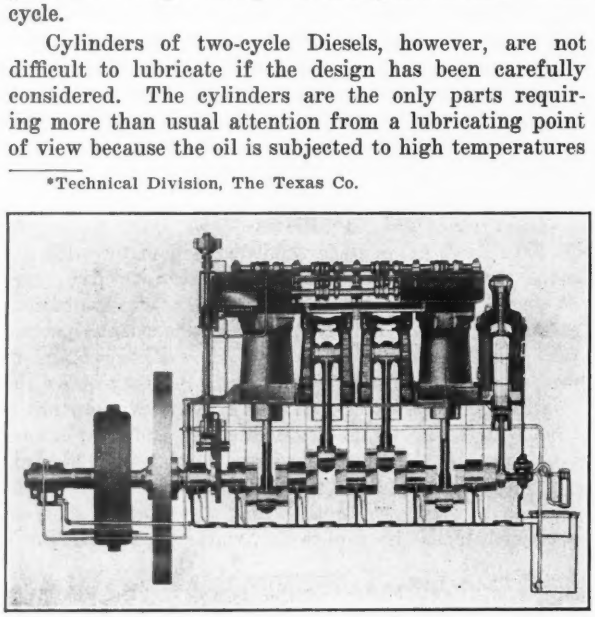


FIG. 1. ONE GRADE OF LUBRICANT IS USED THROUGHOUT THIS FOUR-CYCLE AIR-INJECTION ENGINE. GEARED PUMP DRIVEN FROM CRANKSHAFT FEEDS LUBRICANT TO BEARINGS AND GEARS

Effect of Temperature on Oil Film

A large portion of the cylinder wall over which the piston passes is swept by flame every stroke in a two-cycle engine and every other stroke in a four-cycle engine. This flame starts with a temperature of at least 2000 deg. F. and the maximum temperature of the gases in Diesel engine cylinders ranges in the neighborhood of 2700 deg. F. or even higher. The maximum temperature decreases as expansion of the burning charge and exhaust take place and gradually rises during the compression stroke. The minimum temperature is in the neighborhood of 250 deg. F. while the average during a complete cycle is probably 950 deg. F. These temperatures refer to the gases, of course, and not to the cylinder walls.

It is assumed that the cylinder walls have a temperature of only about 30 deg. F. above that of the circulating water. As long as the circulating water is not boiling, it is safe to assume that the cylinder wall temperature is not above 250 deg. and the temperature

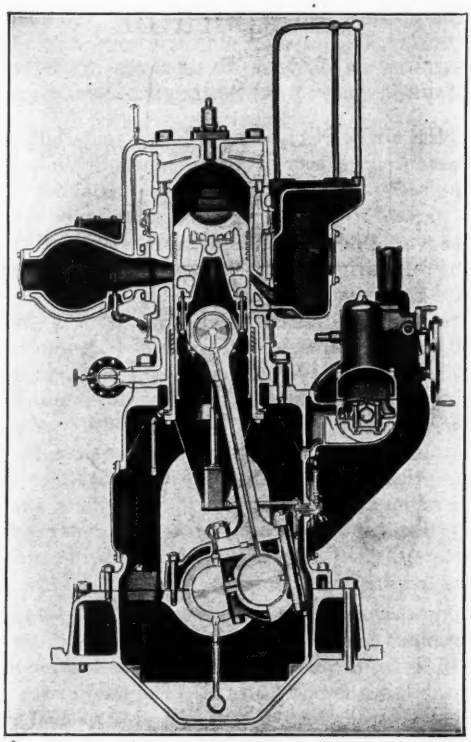


FIG. 2. LUBRICATING AND COOLING SYSTEMS OF A TWO-CYCLE, AIRLESS-INJECTION ENGINE

of the piston not much higher. With proper cylinder and piston circulating medium, therefore, the high temperature of the gases need cause no great concern. Most oils used for Diesel engine cylinder lubrication have a flash point higher than 350 deg. F. Lubricating oil does not burn readily and the time it spends in the cylinder is short. An engine running at only 100 r.p.m. would expose the lubricated surface of the cylinder to the action of the flame for less than one-quarter of a second. At higher speeds the time allowed for the oil to burn is so short that a flash point of probably 300 deg. F. would be high enough except under unusual conditions. Operating factors on which the temperatures depend include the temperature, the velocity and the quantity of cooling water, the quantity of heat necessary to be conducted per unit of area through the cylinder walls, the diameter of the cylinder, the thickness of the liners and the load developed by the engine.

Effect of Pressures on Oil Film

With pressures rapidly increasing during the compression stroke, until a maximum of about 500 lb. per sq. in. is reached in the cylinders, it is the duty of the oil film to reduce leakage of the compressed gases to a minimum. The highest pressure is, naturally, behind the uppermost ring, being nearly as great as that on the piston head itself. These pressures tend to force the rings against the cylinder wall, producing a squeezing action, which the lubricating oil film must support.

Influence of temperature on the lubricating oil film also depends on the size of the cylinder. Small bore cylinders are easily lubricated. The amount of heat liberated increases as the square of the diameter and the greatly increased heat effect is probably due to radiant dissipation of heat. Combined with the unavoidable greater thickness of cylinder liners in the larger engines, the temperature difference between the cooling water and the gases in the cylinder will tend to increase. Furthermore, the increased cylinder wall thickness tends to reduce the heat absorbed by the cooling water and increases the temperature of the oil film. As the temperature of the film is greater with large cylinders than with small ones, the former require the use of a somewhat higher viscosity oil for efficient lubrication.

Combined Effect of Temperature and Pressure

The high temperature of combustion in a Diesel cylinder occurs simultaneously with the high pressure. This combined action, especially under adverse conditions, may be detrimental to the oil film, which will tend to thin down; it will enhance, furthermore, the loss of compression and increase cylinder liner wear. Under such conditions of high pressure and temperature, the lubricant must be able to spread rapidly on cylinder walls and to replenish its own lubricating film. It must have film strength even when exposed to high combustion temperatures as well as pressures, and it should maintain a complete piston seal effectively under all conditions. Cylinder liner wear is generally greatest at the combustion ends of cylinders where maximum temperatures and pressures exist.

Oxidizing Influences

If improper methods are used for applying lubricating oil to the power cylinders, oxidation of the oil is greatly increased, forming undesirable products in the new oil before it reaches the cylinders. Necessary details to be considered in the control of oxidation of the oil are the arrangement of the lubricating oil piping, the lubricating oil injection tubes and cylinder, the size of lubricating oil ports in the cylinder liner and the design of the mechanical lubricator.

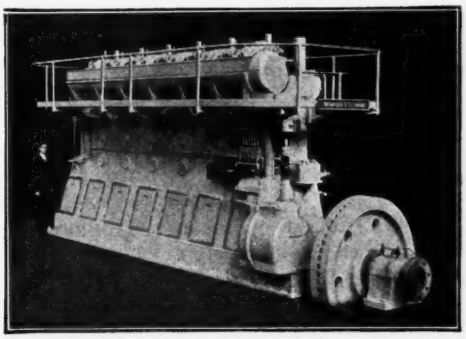


FIG. 3. IN THIS MEDIUM-SPEED, FOUR-CYCLE ENGINE, PISTONS ARE OIL-COOLED, BEARINGS ARE PRESSURE LUBRICATED AND A FORCE-FEED MECHANICAL SYSTEM LUBRICATES CYLINDERS AND AIR COMPRESSOR

Points of Cylinder Oil Delivery

Number of points at which the lubricant should be applied to the piston will depend on the type and size of the engine. Two to four oil holes located equidistantly in the cylinder wall will generally be sufficient, although this, too, will depend upon the bore of the cylinder. These holes are usually located between the first two piston rings when the piston is at its lowest point, although in some engines these oil supply points are found above these positions. One point of delivery is not considered dependable because the opposite side of the cylinder might be under-lubricated. In such cases this can be obviated somewhat by cutting an internal groove in the cylinder wall to distribute the oil.

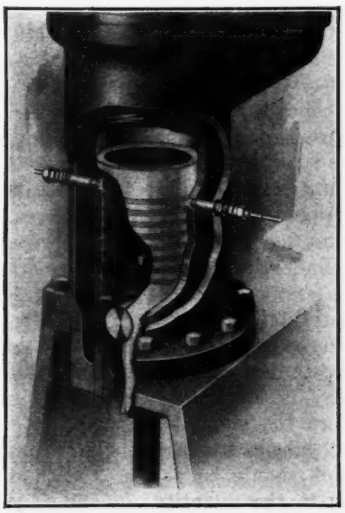


FIG. 4. DETAIL OF CYLINDER, SHOWING TWO POINTS OF LUBRICANT APPLICATION ALTHOUGH NUMBER VARIES WITH TYPE AND SIZE

In the two-cycle engine, care is taken that none of the oil holes are located in line with the exhaust ports, otherwise the exhaust gases would tend to carry off a certain amount of the lubricant.

It is now more or less standard practice to use a separate pump plunger of the mechanical lubricator for each point of oil introduction to secure positive lubrication and to obviate the possibility of one lead receiving more or all of the oil because of difference in resistance at the end of the individual leads. The exact location of the oil feed to the cylinder represents usually

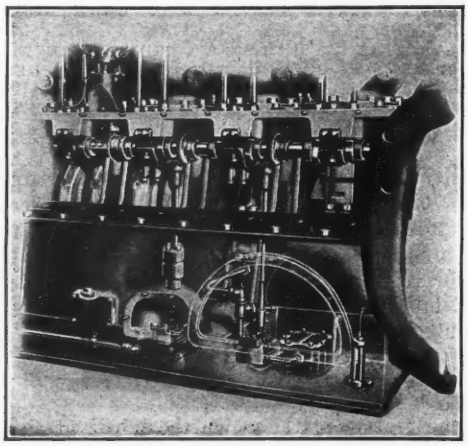


FIG. 5. LOCATION OF FUEL OIL AND LUBRICATING OIL PUMPS AND THEIR DRIVING MECHANISM ON A LOCOMOTIVE DIESEL

the manufacturer's idea of how lubrication is best accomplished.

Quantity of Cylinder Oil Feed

Fewer subjects are more frequently discussed in relation to Diesel engine operation than the amount of lubricating oil necessary for efficient cylinder lubrication. No general figures can be stated as this amount depends upon such factors as the type and construction of the engine, grade and quality of the oil, method of application, number of oil feeds and kind of lubricant employed. Oil engine operators should always be guided by the recommendations of the manufacturers of each type of engine and by their own close observation of the condition of the engine cylinder walls, so that they can gradually reduce the amount of lubricating oil to the most economical degree. With mechanical force feed lubricators, it is often possible to control the oil feed to approximate the theoretical requirements of the engine for the particular oil in service.

While cylinder lubrication is often carried out separately with engines of the enclosed crankcase splash-oiled type, a certain amount of lubrication will be derived from the vaporous fog of lubricant that is present in the crankcase during the operation. The amount of this secondary lubrication cannot be measured accurately therefore the amount by which it could reduce the cylinder lubrication cannot be definitely stated. More attention should be paid to the condition of the oil film than to the quantity.

When heavy fuels are burned, the rate of lubrication to the cylinders must be increased, although this increase cannot be definitely stated because of the many factors involved, but may be expected to vary from 10 to 30 per cent and higher above the regular consumption. Contamination of the piston lubricant by unburnt fuel may occur and in such cases temporary improvement may be effected by syringing the piston and liner with kerosene, afterwards feeding with a copious supply of lubricating oil to preserve the film. Such contamination may be avoided to some extent by giving immediate attention to the fuel valve as soon as any indication of dribbling or faulty atomization becomes evident. Where the piston becomes unusually dirty, the addition of about 20 per cent kerosene to the lubricating oil in the mechanical lubricator will assist materially in keeping the piston clean and eliminating piston grunting. In such a case, the rate of oil sent to the cylinders must be increased to compensate for the reduced lubricating property of the lubricant.

Over-Lubrication

It cannot be too strongly stressed that excessive lubrication of cylinders is detrimental in the long run to

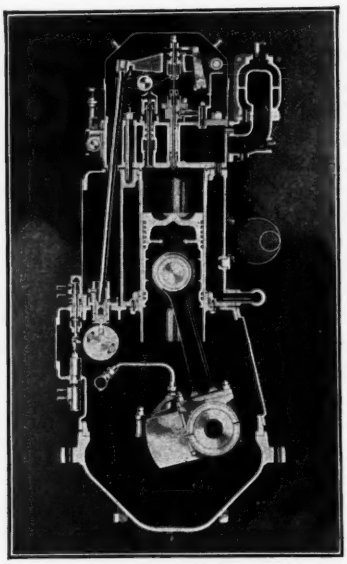


FIG. 6. IN THIS HIGH-SPEED ENGINE, LUBRICATING PUMPS IN CRANKCASE SERVE ALL PARTS OF ENGINE

satisfactory Diesel operation. Even with the most suitable oil, over-lubrication leads to abnormal carbon deposits in the cylinders, which may clog valves or ports. As has been pointed out, this effect is more pronounced in the case of the four-cycle than the two-cycle engine because excess oil may be blown out through the exhaust ports of the two-cycle type.

Carbon deposits in the cylinders are only too frequently blamed on the lubricating oil but, in most cases, care on the part of the engine operator would eliminate this trouble. With fuel regulated to give a clear exhaust and the use of just enough lubricating oil to lubricate the cylinder, carbon troubles will be reduced to the minimum. Such deposits naturally may restrict the area of the exhaust, prevent proper scavenging and lower the volumetric efficiency. Excessive deposits in piston ring grooves are a common cause of improper functioning of the rings, causing blow-by of the gases, destruction of the oil film and excessive wear of both

rings and liners. Deposits on valve seats and spindles are responsible for leakage and loss of power.

Effective distribution of lubricant in a Diesel cylinder will depend to a certain extent on the fit of the piston rings. Loose rings not only decrease the effectiveness of a lubricating oil, but also cause a loss of compression and of power by allowing blow-by to occur. This in turn results in overheating of the lower parts of the cylinder and piston. Dilution of the lubricating oil, however, does not take place as in the carburetor type of engine because the fuel charge is burned completely as fast as it enters the combustion chamber. On the other hand, where the rings are too tight, a scraping action will be exerted over the cylinder walls, breaking or reducing the lubricating film. To counteract this possibility, certain authorities advise slight beveling of the upper edges of the top piston rings to facilitate their sliding over the oil film on the up stroke. Tight, improperly set rings might also lead to seizure of pistons. Unusual conditions may cause a collection of residue around the piston rings so that removal of the piston from the cylinders is made difficult. After the piston is removed, the rings may appear to be embedded in hard carbon but attempts to remove them may cause breakage. If the flame of a small burner is played on the piston for a few minutes, however, the deposit will soften and the rings will spring free.

Safety in the Ice Plant

SERIOUS ACCIDENTS ARE NOT COMMON AND CAN USUALLY BE AVOIDED BY THE ENGINEER AS THEY ARE ALMOST ALWAYS THE RESULT OF CARELESSNESS

OPERATION of ice and refrigeration plants is not ordinarily considered as a hazardous operation, although accidents do sometimes occur and to prevent all danger, it is well to have a gas mask and first aid cabinet available and accessible to the employes. Perhaps the greater source of potential danger is in overfilled cylinders of ammonia. Cylinders, whether overfilled or not, should not be placed on hot floors, near steam lines nor near boilers as the heat expands the gas and an explosion might occur. When ammonia is withdrawn from the system for repairs or inspection, it should never be put into cylinders without weighing before and after. Overfilling is a dangerous practice.

Ammonia receivers are considered a safety measure by many engineers as they enable the operating engineer to pump out of part of the apparatus and store the ammonia without the necessity of withdrawing it completely from the system. Ammonia receivers or storage tanks for liquid ammonia coming from the compressors should be equipped with gage glasses to indicate the amount of the ammonia and these gage glasses should be equipped with automatic stop valves which will operate in case the glass breaks.

There should also be a safety valve on top of the condenser and on top of the ammonia receiver and, as new plants are usually tested on the high pressure side for 300 lb., the condenser valve should be set to about 300 lb. and the receiver at about 350 lb. Outlets of these safety valves should be piped to the roof of the building or to a sewer where there is considerable water flowing. Many cities have ordinances specifying the method of installing safety valves and vents.

Proper handling of ice and ice tongs is another point which cannot be emphasized too strongly. They should always be properly sharpened, the rivets should fit snugly in smooth holes but should not bind and should be replaced when wear allows too much play. The handles should be hollow, smooth and of sufficient size to avoid discomfort to the hand. Practically all types of tongs used in the handling of ice are made with a three faced gripping point and according to the National Safety Council should be sharpened as follows:

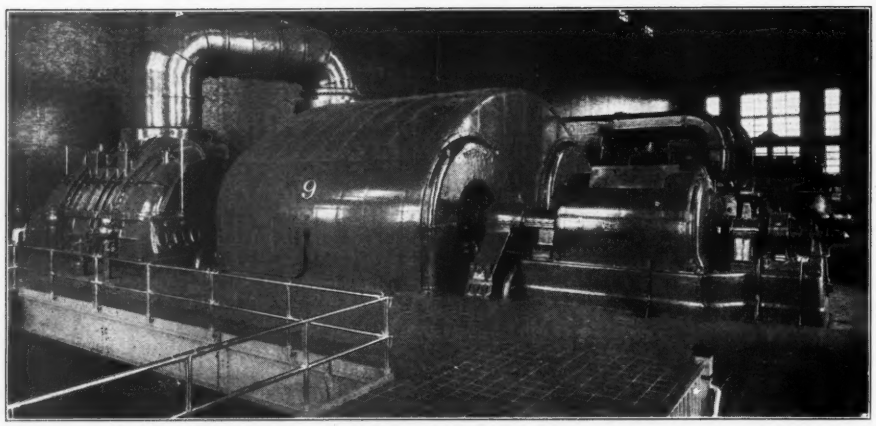
Place one bow of the tongs in a vise with the outside of the bow on top (handle downward), use a flat file of medium size and file on the left top face of the point toward the point end until a perfectly true face, ½ to ¾ of an inch in length, extends from the point back toward the bow, the exact distance depending upon the thickness of the point stock and the angle used. Use the same procedure on the right face of the point.

Then place the tong in the vise with the tong wide open with the inside of the bow on top. File the inside face lightly toward the point, keeping the surface flat and removing only sufficient metal to take off the feather edges caused by filing the angle faces. All three faces thus filed should terminate in a needle point with the point in the center at the inside flat face. When completed, the needle point should be filed off lightly so as to make it slightly blunt. A blunt point on the tongs is just as effective as a needle point, will retain its sharpness much longer and is not as dangerous to the worker. The inside face of the tong point should have sufficient width to avoid tearing through score mark or through soft ice.

When pulling ice from or to ice chute doors, the workman should take a firm grip on the top edge of the block 6 or 8 in. from the end and properly set the tong points into the ice before effort is exerted on the handle. The point should not be set on a score mark.

In up-ending ice in the storage room, the workman should take a firm grip on the end of the block about 3 or 4 in. from the floor and set the points of the tong securely before making the lift. One man is sufficient for a 300-lb. block but for a 400-lb. block, two men should be used if possible, preferably with the two men handling the one pair of tongs. Using the same tong, both men exert their lifting effort together, which gives them perfect control of the block until it is securely placed on end. There is also less opportunity for the workman to lose control of the block and less danger for strained body muscles and crushed toes.

When taking the ice off end, the usual and safe method is to reverse the operation as mentioned above. This method is, however, comparatively slow and in many plants the 300-lb. block is safely taken off end by the tilting or tipping process. That is, a grip is taken on the top of the block and the flat side tilted toward the workman. While the block is thus tilted an experienced man can change the grip of the tongs to the back edge of the block and permit it to fall to the floor, striking at the corner of the block where the wide and narrow faces meet. This can be done with solid ice with every little breakage and by experienced men with little danger. Metal toe guards should be worn by men employed in storage room work.



In The Turbine Room at Hell Gate Station

One of the two 160,000 kw. turbo-generators is shown in the foreground.

The Power Behind New York

Part III.

Recent developments in the three major generating stations of the New York Edison System.

IN ANY SYSTEM, the ability to generate and distribute electrical energy continuously and reliably is to a great extent dependent upon the good design of the generating stations in which the energy is produced. In all cases the generating plant is the starting point of all economical operation. In the preceding articles, we have described the New York Edison System as a whole and have discussed somewhat superficially the more important aspects of system operation.

It will now be our purpose to consider in some detail the design features of the three major stations, i.e., Hell Gate, Hudson Avenue and East River Stations and to outline the underlying reasons connected with their design.

To do this, it will be most convenient to consider each of these stations separately, pointing out the features of principal importance in each case and then, in a summary, to discuss together the three stations so as better to understand their differences.

We shall begin with a general description of Hell Gate since this is the oldest of the three. This will be followed by a similar description of Hudson Avenue and finally of East River Station.

Features of Hell Gate Station

Hell Gate Station was first placed in operation in November, 1921. At that time the plant contained two 60-cycle, Westinghouse, tandem compound turbo-generators of 40,000-kw. capacity and two 25-cycle General Electric units of 35,000-kw. capacity. Steam was supplied by twelve 1890-hp. Springfield boilers each fired by two Taylor underfeed stokers, with a double-ended arrangement and a central clinker pit. At the time the initial installation was made, it was anticipated that this general scheme would be carried out so far as increments of turbine capacity were concerned, at least.

At that time, too, the general plan of the electrical system was worked out. The electrical galleries were located in a separate building, parallel with the boiler room, but connected to it by a number of bridges. The vertical isolated phase arrangement was decided upon and this has not been altered even in the final sections. The 25 cycle generators operate at 11,400 v. while the 60-cycle machines are wound for 13,200 v.

The house supply for the initial installation was furnished by two 2000-kw. 2300-v. steam driven generators. These were supplemented at a later date by two additional 2000-kw. generators driven direct from the shafts of units number 6 and 7.

Following the initial installation of these four units in 1921, the next unit to be installed, in 1923, was a 25-cycle General Electric unit practically duplicating the previous 25-cycle units. The three boilers for this unit, however, were fired by single underfeed stokers having 33 tuyeres and water-cooled side walls in the furnace. *This was the first installation anywhere in which this type of water-cooled furnace wall was adopted.* The boilers for this unit contained less surface than the original installation but were provided with economizers. The 12 original units had no economizers.

At the time the original installation was made, the long stokers were not available, their development taking place during the period between the first and second installations.

So rapid was the growth of the system that by the time turbine units No. 6 and No. 7 were required, it

was found desirable for economic reasons to provide greater capacity in the space which was available, so two 60-cycle Westinghouse machines of 50,000-kw. each were installed; thus, the station equipment consisted of two 40,000-kw., 60-cycle units, three 35,000-kw., 25-cycle units and two 50,000-kw., 60-cycle units.

Boiler units provided to supply these 50,000-kw. machines were substantially of the same general design as those of the previous installation; that is, they were equipped with single underfeed stokers, water-cooled furnace walls and economizers. It had been learned from earlier experience that boilers were capable of much greater outputs than those delivered by the conventional boiler and stoker combinations used in earlier plants. Economic conditions indicated that the ratio of grate surface to boiler surface should be substantially increased over the prevailing practice. As a result, the boiler surface provided per unit of turbine capacity in Hell Gate Station was less than that provided in most other stations and necessitated high ratings.

Hell Gate Station was originally designed for an ultimate capacity of 310,000-kw. contained in 8 units and 24 boilers. By the time the load conditions required the installation of the eighth machine in 1928, enormous strides had been made in turbine manufacture, so it was decided to install the largest unit which could be accommodated in the remaining available space. This was found to be a machine of 160,000-kw. capacity of the cross compound type.

It is interesting at this point to consider how the conditions under which the initial units were installed affected the choice of this last 160,000-kw. machine, which was *four times the capacity of the initial machines.*

The choice of the tandem compound 60-cycle units for the first installation was fixed largely by economic and manufacturing conditions existing at that time. The 40,000-kw. units provided were the largest single shaft machines available. The tandem arrangement necessitated a wide turbine room. This was fortunate, however, for it was this wide turbine room which made possible the subsequent installation of a 160,000-kw. unit in the space originally provided for a 40,000-kw. unit. Although this was finally accomplished, many serious obstacles had to be overcome before success was attained.

A critical study of conditions indicated, however, that a single 160,000-kw. generating unit on a system

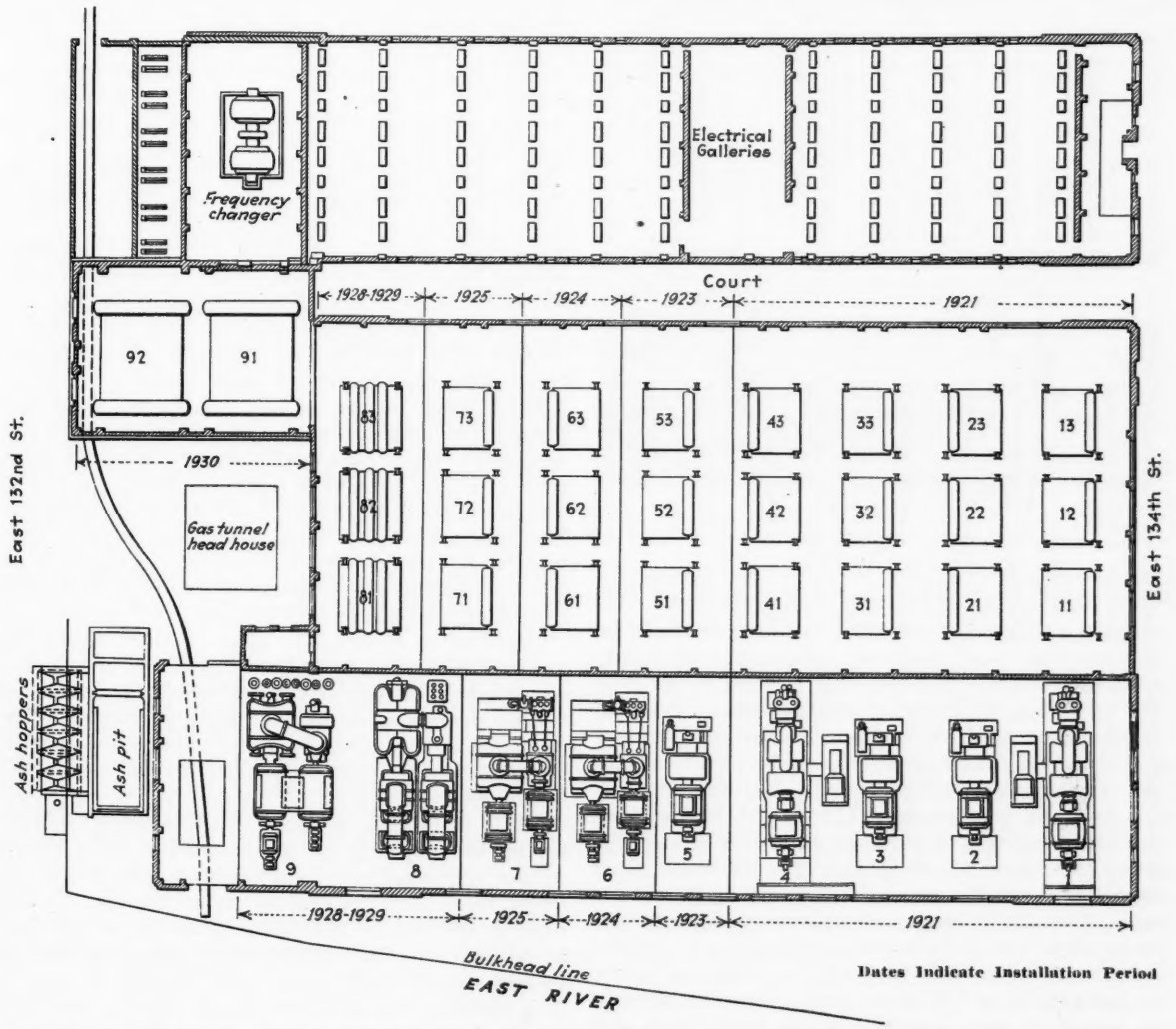


FIG. 1. GENERAL PLANT LAYOUT FOR HELL GATE STATION, SHOWING TIME OF EACH INSTALLATION. THE STATION IS NOW COMPLETED

in which all other units are of smaller capacity is somewhat inflexible and since it was evident that an additional unit or a new plant would be needed not far in the future, it was decided to install two 160,000-kw. machines instead of one, This, of course, necessitated extending the building, which was done. The first 160,000-kw. machine (No. 8) is an American Brown Boveri machine, but was constructed in Switzerland, while the second unit (No. 9) is a Westinghouse machine. These machines were installed in 1928 and 1929.

The station steam pressure is 265 lb. gage, this limit being set by the 12 original boilers which were built for a maximum pressure of 300 lb. At the time of

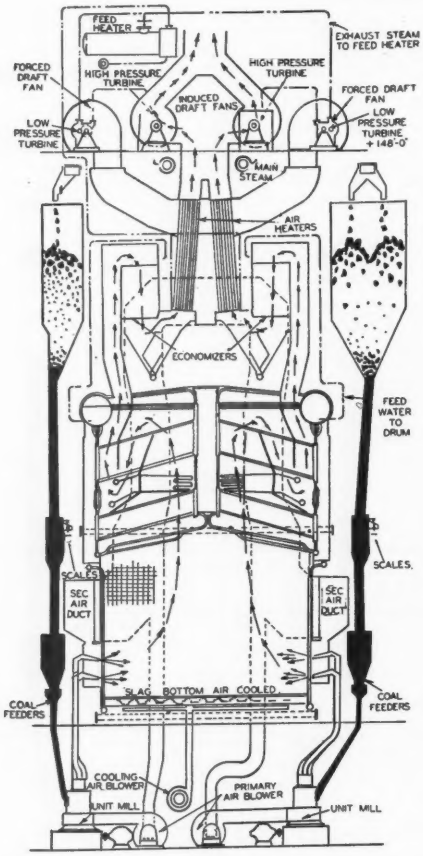


FIG. 2. CROSS SECTION OF ONE OF THE 800,000 LB. PER HR. BOILERS AT HELL GATE

purchasing the new 160,000-kw. units studies were made to determine the possible gain which might result from the use of higher pressures on these units. Practical considerations, however, decided in favor of continuing at the original design pressure in order to take advantage of the diversity in boiler steam demand made possible by such arrangement. The use of higher pressures on these two units would have necessitated the immediate installation of a high-pressure boiler plant capable of supplying the entire capacity of these units besides introducing serious operating complications and loss of flexibility in boiler room control.

In order to provide part of the additional steam for units No. 8 and 9, three boilers were installed in the remaining space available in the boiler room and designed to deliver just as much capacity as possible consistent with economy from the space available.[1] Each of these boilers has a nominal rating of 2400 hp. including water-cooled walls on all four sides of the furnace and are fired by pulverized coal using unit mills and the tangential method of firing. These units have a maximum rating of about 400,000 lb. of steam per hr. They are provided both with economizers and air heaters, the two being arranged in parallel due to space limitations, to decrease the draft resistance and to provide temperature control on the preheaters.

While the use of puverized fuel on these three units was new at Hell Gate, it was by no means an experiment. For several years the company had operated pulverized coal fired boilers at Sherman Creek Station and it was because of the success with this type of fuel there that led to its adoption for the three new units at Hell Gate.

While these three new boilers furnished boiler capacity for the two 160,000-kw. generating units, they were not sufficient, so during 1930 an addition was built to the boiler room and two additional boilers installed. These are now known as boiler units Nos. 91 and 92. The three previously installed were Nos. 81, 82 and 83.

The two latest boilers (Nos. 91 and 92) are almost twice as large as the three previous units and each has a nominal rating of 800,000 lb. of steam per hour, but this is by no means the maximum capacity that can be attained. A cross section through one of these units is shown in Fig. 2. They are fired by pulverized coal and like the three preceding units use the molten slag method of ash removal.

An interesting feature regarding these two new boilers is the arrangement of equipment for supplying air for combustion. This arrangement was described in detail in the April 1, 1931, issue of Power Plant Engineering but brief reference to the principal features will be of interest here. Four induced draft fans each of 125,000 c.f.m. and two forced draft fans each of 150,000 c.f.m. are installed for each boiler. The induced draft fans operate in pairs, each pair having a common shaft, driven through a reduction gear by a 974-hp. high-pressure turbine operating at 7500 r.p.m. maximum. The forced draft fans are operated singly and are driven through a reduction gear by a 393-hp. low-pressure turbine operating at 6000 r.p.m. maximum. The high pressure turbines driving the induced draft fans, and these in turn exhaust into a closed water heater against a back pressure of from 5 to 25 lb. gage depending upon the boiler load.

Installation of these two boilers in 1930 marked the final completion of Hell Gate insofar as extension is concerned. The property upon which the station is located permits of no further building extension but, of course, it would be possible to increase the capacity of the station by replacing some of the early units with larger ones.

It is of interest to study the tremendous increase in the size not only of the generating units in this station over a period of ten years but also that of the boiler units. The generating units increased in size from 40,000-kw. to 160,000-kw. and the boilers from units rated at about 200,000 lb. of steam per hour to the two latest which deliver over 800,000 lb. per hr. This steaming capacity, however, is not the maximum

[1] These boilers and also the new generating units were described in the June 1, 1929, issue of Power Plant Engineering.

that can be obtained. At the present time, the boiler capacity is limited by the size of the feedwater lines and valves.

No better conception of the engineering progress made in and shown by Hell Gate Station in 10 yr. can be had than by means of the following ratios.

	Area Sq. ft. per kw. Original Units 1-4	Recent Units 8-9	Completed Station
Turbine room	0.113	0.029	0.069
Boiler room	0.175	0.071	0.105
Boiler and turbines	0.288	0.100	0.174
Electrical galleries	0.149	0.070	0.074
Total	0.437	0.170	0.248

	Volume Cu. ft. per kw. Original Units 1-4	Recent Units 8-9	Completed Station
Turbine room	14.0	3.83	8.71
Boiler room	21.7	9.72	13.55
Boilers and turbines	35.7	13.55	22.26
Electrical galleries	17.0	8.00	8.39
Total	52.7	21.55	30.65

These ratios reflect the structural savings rendered possible by a far sighted policy in the selection of large units. Contrasted with the combined economics made possible by the choice of large units building savings become merely incidental. When the plant ratios are considered as comparative measures of investment efficiency, however, the physical factors given in this table become far more significant.

There is no other station, perhaps, in which the advances in the art during the past decade are more strikingly illustrated than they are in Hell Gate. It is noteworthy that the most recent units were installed without disturbing the architectural harmony of the structures which were designed for the initial installation.

Developments at Hudson Avenue Station

Hudson Avenue Station, the major source of supply for the Boroughs of Brooklyn and Queens, was placed in operation in May, 1924, with one 50,000-kw. generating unit. A second 50,000-kw. machine was started in June and a third in October, of the same year. These three 50,000-kw. machines constituted the initial installation and, at the time they were ordered, were the largest single shaft machines available.

In order better to understand the design of this station, it will be of interest briefly to consider the conditions which required the construction of this station.

Brooklyn for some time had been growing in population with great rapidity. Since this growth was expected to continue for many years, it was evident that any new generating station designed to meet the electrical requirements of this growing community should be flexible enough to accommodate any variations in rate of growth that might develop. It required the determination of the fundamental lines of engineering development for a rapidly developing future of enormous possibilities.

As has been pointed out in previous articles, Brooklyn undertook electric generation and distribution at an early date and for a long time development took place in directions along lines first started. With a new undertaking under way, it was now necessary to appraise the earlier developments to determine whether they were in line with modern tendencies and whether they could well be perpetuated or whether drastic modification was inevitable.

The condition created by the early use of direct current has already been discussed in a preceding article. It was clearly desirable that Hudson Avenue Station should develop at the standard frequency of 60 cycles. It was also found economical to install a 35,000-kw. frequency changer which would make the low operating costs of the new station available to the existing 25-cycle system, at the same time providing a continuance tie between the two generating systems. This frequency changer is of the synchronous-synchronous type.

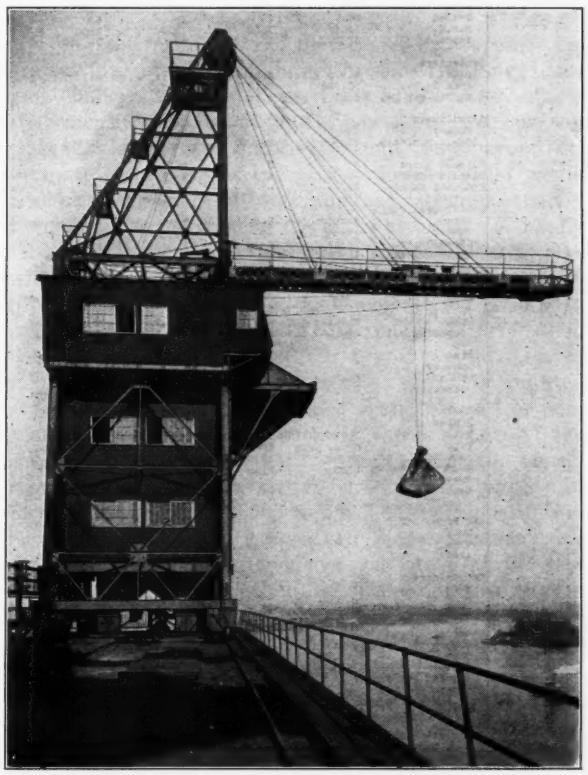


FIG. 3. ONE OF THE COAL TOWERS AT HELL GATE

A change in the transmission and distribution voltage also was in order. Previously the Brooklyn system had been on a 6600-v. basis with a tentative approach to 13,200 v. for transmission. The mere problem of getting the output of Hudson Avenue through the streets surrounding the station made 13,200 v. transmission impractical, so 26,400 v. was decided upon. Fortunately, the larger size of substations (these had been increased from 20,000 to 30,000 kv-a.) justified this voltage.

Quadrupling the prevalent transmission voltage was quite an undertaking at that time, not only because of the insulation problems introduced, but also because it necessitated the abandonment of air blast and the initiation of oil-cooled transformers in the substations.

Hudson Avenue was originally designed to contain eight 50,000-kw. units, but the load has grown so rapidly and developments in engineering practice have been so enormous that the last two units (Nos. 7 and

8) alone, which are now being installed, total 320,000 kw.

The first three units installed in 1924 operated at 280 lb. steam pressure. Advance in machine design and improvement in characteristics of available metals made use of larger generating units and higher steam pressures not only desirable but practicable, therefore, the remainder of the station was standardized at 400 lb. load and to insure adequate system protection. This culminated in the purchase of two complete units to be known as Nos. 7 and 8. These machines are now being installed, unit No. 7 going into operation in September, 1931, and No. 8 in April, 1932. They are General Electric machines operating at 1800 r.p.m. and are tandem compound with single flow in the high and double flow in the low pressure cylinders. Each tur-

TABLE I. PRINCIPAL EQUIPMENT INSTALLED AT HELL GATE

UNIT NO.	1	2	3	4	5	6	7	8	9
Commissioned	1921	1921	1921	1921	1923	1924	1925	1928	1929
Turbo-Generator									
Make	W.E.& M.Co.	G.E. Co.	G. E. Co.	W.E. & M. Co.	G. E. Co.	W.E. & M.Co.	W. E. & M.Co.	Brown Boveri	Westinghouse
Type	Tand.Comp.	Single Cyl.	Single Cyl.	Tand. Comp.	Single Cyl.	Cross Comp.	Cross Comp.	Cross Comp.	Cross Comp.
Rating - Kw.	40,000	35,000	35,000	40,000	35,000	50,000	50,000	160,000	160,000
Power Factor	80%	80%	80%	80%	80%	80%	80%	85%	85%
Cycles	60	25	25	60	25	60	60	60	60
R.P.M.	1800	1500	1500	1800	1500	1800	1800	1800	1800
Voltage	13,200	11,400	11,400	13,200	11,400	13,200	13,200	13,800	13,800
Condensers									
Make	W.E.& M.Co.	Worthington	Worthington	W.E. & M. Co.	Worthington	W.E. & M.Co.	W. E. & M.Co.	W. E. & M.Co.	W. E. & M. Co.
Area Sq.Ft.	50,000	50,000	50,000	50,000	50,000	53,000	53,000	137,000	137,000
Sq.Ft. per Kw.	1.25	1.43	1.43	1.25	1.43	1.26	1.30	0.86	0.85
Circulators									
Number	2	2	2	2	2	2	2	2	2
Cap.g.p.m.each	35,000	35,000	35,000	35,000	35,000	40,000	45,000	77,500	77,500
Hotwell pumps	2	2	2	2	2	2	2	3	3
Steam Ejectors	-	4	4	-	-	2	1	3	3
Hyd. Air Pumps	2	-	-	2	4	-	-	-	-
Boiler Feed Pumps									
Make	Worthington	Worthington	Worthington	Worthington	Buffalo S.P.Co.	Buffalo S.P.Co.	Worthington	Bethlehem	Dean Hill
Number	1½	1½	1½	1½	2	1	2	2	2
Steam Driven	½	½	½	½	1	-	1	2	2
Motor Driven	1	1	1	1	1	1	1	-	-
Cap.each g.p.m.	1000	1000	1000	1000	1200	1200	1200	2000	2000
Feed Water Heaters									
Closed									
Number	1	1	1	1	2	2	2	8	9
Make	Wheeler C&E	Wheeler C&E	Wheeler C&E	Wheeler C&E	Croll Reynolds	Croll Reynolds	Croll Reynolds	Elliott	Cochrane
Capacity	350,000 lb.	350,000 lb.	350,000 lb.	350,000 lb.				3,570,000 total	3,202,700 total
Open									
Number	1	1	1	1	-				
Make	Cochrane	Cochrane	Cochrane	Cochrane	-			1928-1929	1930
Capacity	350,000 lb.	350,000 lb.	350,000 lb.	350,000 lb.	-				
Boilers									
Number	3	3	3	3	3	3	3	3	2
Make	Springfield	Springfield	Springfield	Springfield	Springfield	Springfield	Springfield	Springfield	
Type	Cross drum	Cross drum	Cross drum	Cross drum	Cross Drum	Cross Drum	Cross Dum	Cross Drum	Cross Drum
Heating Surface	18,900	18,900	18,900	18,900	15,500	12,100	12,100	20,000	
Superheater	2135	2135	2135	2135	7410	10,450	4000	4800	
Water walls	-				-	-	-	-	
Water wall surface					400	450	450	3800	
Air Preheater									
Make					-	-	-	Combustion Eng. Co.	
Type					-	-	-	Plate	
Area					-	-	-	11,840	
Economizers									
Make					Power Spec.Co.	Sturtevant	Power Spec.Co.	2 Foster Wheeler & 1 C.E. Co.	
Type					Foster	Steel Tube	Foster	Foster	Fin Tube
Area					13,824	12,100	10,692	26,136	27,836
Stokers									
Number per boiler	2	2	2	2	1	1	1		
Make	Am.Eng. Co.	Am. Eng.Co.	Am. Eng. Co.	Am.Eng. Co.	Am.Eng. Co.	Am.Eng. Co.	Am.Eng. Co.		
Type	Taylor	Taylor	Taylor	Taylor	Taylor	Taylor	Taylor		
Retorts per stoker	14	14	14	14	14	14	14		
Tuyeres	-	-	-	-	33	33	33		
Proj.grate area per boiler	472	472	472	472	337.7	377.7	377.7		
Pulverized Coal								1928-1929	1930
Make System								Comb. Eng. Co.	
Type								Unit	
Type mills								Impact	
Type burners								Tangent	
No. burners per boiler								4	
Furnace Vol.cu.ft.	8000	8000	8000	8000	6500	6500	6500	18,800-21,840-18,150	
Forced Draft Fans									
Number	2	2	2	2	2	2	2	1 per boiler	
Make	Sturtevant	Sturtevant	Sturtevant	Sturtevant	Sturtevant	Sturtevant	Sturtevant	Sturtevant	
Type	-	-	-	-	-	-	-	-	
Static head in H_2O	7	7	7	7	7	7	7	10	
Capacity c.f.m.	130,000	120,000	120,000	120,000	120,000	120,000	120,000	155,000	
Induced Draft Fans									
Number	3	3	3	3	3	3	3	1 per boiler	
Make	Sturtevant	Sturtevant	Sturtevant	Sturtevant	Sturtevant	Sturtevant	Sturtevant	Sturtevant	
Static Head in H_2O	6	6	6	6	6	6	6	14	
Capacity	140,000	140,000	140,000	140,000	140,000	140,000	140,000	275,000	

The fourth unit, an 80,000-kw., cross compound machine and the first to operate at the higher pressure, was placed in service in October, 1926. In September, 1929, and October, 1930, units 5 and 6 respectively were put into operation. They are duplicate units, each rated at 110,000 kw. and are of cross compound construction. Thus at the end of 1930, Hudson Avenue had an installed generating capacity of 450,000 kw.

The operation of Hudson Avenue Station as a major unit of the New York Edison System made necessary further station capacity to provide for an increasing

bine will be direct connected to a single generator of 160,000 kw. The compactness of these units is shown by the fact that an output of 100 kv-a. will be obtained per square foot of floor area.

These two units will be served by eight boilers of the special Ladd type constructed by the Combustion Engineering Corporation. Designed for 24,450 sq. ft. of boiler heating surface, equipped with a C.E. return bend economizer and Elesco Superheater, each boiler unit is guaranteed for a maximum evaporation of 530,000 lb. of steam per hour.

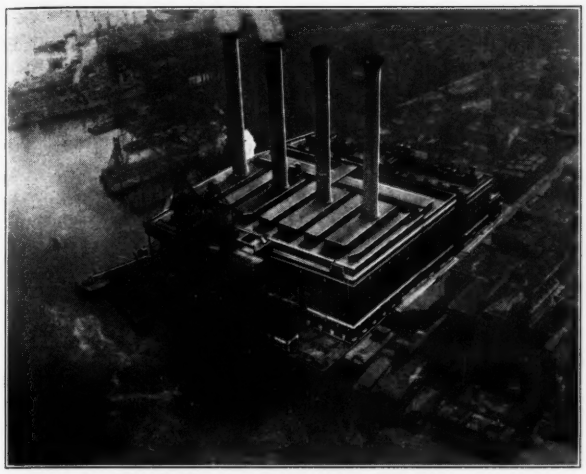


FIG. 4. HUDSON AVE. STATION

Each boiler is served by a single 15-retort underfeed stoker 26 ft. wide and 27 ft., 8 in. long, designed by the American Engineering Corporation. They will have a length of 69 tuyeres, a projected grate area of 694 sq. ft. and will be capable of burning 56,000 lb. of coal per hour. The furnace volume will be 15,500 cu. ft.

Thus in April, 1932, when unit No. 8 goes into operation it will mark ten years of almost continuous design and construction. The installed turbine capacity will then be 770,000 kw. or over 1,000,000 hp.

Because of the two boiler pressures, Hudson Avenue may be considered to be two complete generating stations. The first three generating units with their 12 boilers and auxiliaries operating at 280 lb. is known as the low pressure station, while the turbines, boilers and auxiliaries operating at 400 lb. is known as the High Pressure Station. These two stations operate more or less as independent units but they are tied together electrically by bus ties and by one steam tie in the boiler room which operates through a throttling valve and desuperheater. This steam tie is used in cases of emergency and also when the arrangement of available equipment is such as to make its use economical.

A general idea of the developments which have taken place in Hudson Avenue Station in 10 yr. may be obtained from Table II which presents a summary of the major equipment in the entire station.

In considering the recent developments in Hudson Avenue, it will be of interest to discuss some of the factors which led to the selection of the equipment used. Since the original plan for the development of the power supply for Brooklyn was put into effect, two factors had entered the picture, requiring certain modifications in the details of the plan.

First among these was the development of the network system of supply, fed directly through distribution transformers from 27,000 v. without the intervention of sub-stations and second, the phenomenal growth in the size of generating units. The growth in the size of Brooklyn and the consolidation of the various companies throughout the city of New York made it feasible to take advantage of the economies of these extremely large units.

The increase in the size of the load of the system made it possible to increase the size of feeders without appreciably changing the proportion of feeder size to load and the consequent effect upon the system when the feeder is taken out of service. In order to secure this increase in capacity the size of new feeder cables is being increased to the maximum that can be put into the ducts and two cables each going to a different part of the system are connected to one feeder circuit breaker as fast as the increased feeder outlets are required.

When it was found advisable to use 110,000-kw. machines for Units 5 and 6, the design was so worked out that no changes were necessary in the bus connections except that of increasing the current carrying capacity of the conductors immediately associated with these units and the bifurcation of the two feeder sections.

With the installation of the 160,000-kw. turbine generators for units 7 and 8, however, some rearrangements and changes in connections were found necessary as the concentration of so much power in two bus sections would increase the short circuit duty beyond the interrupting rating of the present breakers and would necessitate breakers of larger current carrying capacity than could be installed in the space available. A happy solution was secured by designing the autotransformers with divided high voltage windings, each half to supply a different bus section, made possible by reconnecting the second unit to feed into the same bus section with the first unit, and the fourth unit to feed into the same bus section with the third unit. This relieved space so that one half of each of 7 and 8 could be connected directly to feeder buses in the first part of the generating station. With this arrangement the generating capacity per bus section will be made more uniform, varying from 80,000 to 130,000 kw. capacity and it will be possible to connect all feeder sections with the exception of one, to one or the other of the last two and most economical units. These changes require some relocation of breakers in order to secure adequate current carrying capacity but no scrapping of breakers is necessary.

The new generating units will be single shaft machines wound for 16,500 v. instead of 13,800 v., as it was found that the most economical combination of generator and autotransformer could be secured at this voltage. Fortunately the autotransformers for these larger units can be installed in the same size compart-

FIG. 5. NO. 5 UNIT AT HUDSON AVE. A 110,000-KW. CROSS COMPOUND UNIT

ments provided for the first units and the ventilation will be adequate. The increase in efficiency of the auto-transformers as the size increased and the art progressed has resulted in losses of the largest units but little greater than those of the first units.

With the addition of the second half of the station, some modifications in the scheme of auxiliary supply were undertaken with a view toward more complete operation on the unit principle and reducing costs. The increase in size of units gave the unit system some advantages over the group system and the philosophy of so sectionalizing that trouble in one unit or section would not communicate to other sections was extended. Normal power supply for each unit was taken from two buses connected to a tertiary winding in the auto-transformer of that unit. A so-called common bus was provided divided into two sections each supplied by a transformer connected to a different section of the main bus to which any of the auxiliary buses are automatically connected whenever there is no voltage on the autotransformer of the normal supply. This makes it possible to supply such auxiliaries as are necessary whenever a unit is shut down and also provides automatic transfer to an alternate source of supply if some accident reduces the voltage of the autotransformer to a low value. A house turbine generator unit may be connected to the common bus in case of necessity.

Each type of essential auxiliaries such as circulating pumps, fans, boiler feeds, etc., is supplied by two or more devices the loss of any one which would not seriously cripple the unit. It was therefore believed safe operating practice to connect several auxiliaries of different types to one feeder cable through non-automatic subway type breakers, the cable being protected

TABLE II. PRINCIPAL EQUIPMENT INSTALLED AT HUDSON AVE.

UNIT NO.	1	2	3	4	5	6	7	8
Commissioned	1924	1924	1924	1925	1925	1930	1931	1932
Turbo-Generator								
Make	G. E. Co.	W.E. & M.Co.	W.E. & M. Co.	W. E. & M.Co.	W.E. & M. Co.	W.E. & M. Co.	G. E. Co.	G. E. Co.
Type	Single Cyl.	Trand. Comp.	Trand. Comp.	Cross Comp.	Cross Comp.	Cross Comp.	Tand. Comp.	Tand. Comp.
Rating - Kw.	50,000	50,000	50,000	80,000	110,000	110,000	160,000	160,000
Power Factor	80%	80%	80%	90%	80%	80%	80%	80%
Cycles	60	60	60	60	60	60	60	60
R.P.M.	1200	1200	1200	1800	1800	1800	1800	1800
Auto-Transformer								
Number	3	3	3	3	3	3	3	3
Make	G.E. Co.	C.E. Co.	W.E. & M.Co.	W. E. & M.Co.	W.E. & M.Co.	W. E.& M. Co.	G. E. Co.	G. E. Co.
Rating Kw-a	20,800	20,800	20,800	29,667	45,833	45,833	66,667	66,667
Tert.Wind.Kw-a		-		-	3000	3000	2500	2500
Gen. Air Coolers								
Make	G.E. Co.	Griscom-Russell	Griscom-Russell	Griscom-Russell	Griscom-Russell	Griscom-Russell	G.E. Co.	G. E. Co.
Area Sq.ft.								
(Condensate)	-		-	14,700	28,440	28,440	35,600	35,600
(Salt Water)		25,280	25,280	6,072	10,680	10,680	17,800	17,800
Condenser								
Make	W.E.&M.Co.	W.E. & M.Co.	W.E. & M.Co.	W.E. & M.Co.	W.E. & M.Co.	W.E. & M.Co.	Worthing-ton	Ingersoll-Rand
Area sq.ft.	70,000	70,000	70,000	80,000	85,000	88,500	100,500	101,000
Passes	2	2	2	2	1	1	1	1
Circulators								
Number	2	2	2	2	2	2	2	2
Capacity g.p.m.	51,665	51,665	51,665	50,850	67,500	67,500	73,000	73,000
Hotwell Pumps	2	2	2	2	2	2	2	2
Steam Ejector	1	1	1	1	1	1	1	2
Hyd. Air Pump	1	1	1	1	1	1	-	-
Boiler Feed Pumps								
Make	Buffalo	Buffalo	Buffalo	Cameron	Cameron	Cameron	Cameron	Cameron
Motor Driven	2	1	1	3	2	2	3	3
Steam Driven	-	-	1	1	1	-	-	-
Head lb/sq.in.	400	400	400	600	600	600	600	600
Capacity g.p.m.	1500	1500	1500	1000	1750	1750	1750	1750
Closed Feedwater Htrs								
Number	2	2	2	4	2	2	2	2
Make	Wheeler	Wheeler	Wheeler	Griscom-Russell	W.E.& M.Co.	W.E. & M.Co.	Heat Transfer Products Co	
Passes	4	4	4	4	4	4	4	4
Area (See Heat Balance Diagram)							4600 H.P. 4900 L.P.	4600 H.P. 4900 L.P.
Boilers								
Number	4	4	4	4	4	4	4	4
Make	B&W	B&W	B&W	B&W	B&W	B&W	C.E.Corp.	C.E.Corp
Type	Cross Drum	Cross Drum	Cross Drum	Cross Drum	Cross Drum	Cross Drum	Spec. Ladd	Spec. Ladd
Heating Surface								
Boiler	19,650	19,650	19,650	22,920	23,764	24,700	24,450	24,450
Superheater	2508	2508	2508	3133	3037	4080	5800	5800
Water walls	-	-	-	Bare tube	Bailey	Bailey	C.E. Fin.	C.E. Fin.
Surface	-	-	-	1540	1322	1252	3750	3750
Air Preheaters								
Make				C.E.Corp.				
Type				Plate				
Area sq.ft.				43,290				
Economizers								
Make					B&W	Foster Wheeler	C.E.Corp.	C.E. Corp.
Type					Return Bend	Foster	Fin Tube	Fin Tube
Area Sq.ft.					14,974	21,420	22,400	22,400
Stokers								
Make	C.E. Corp.	W.E.& M.Co.	C.E. Corp.	W.E. & M.Co.	W.E.&M.Co.	W.E.& M.Co.	Amer.Eng.Co.	Amer.Eng.Co.
Type	Underfeed	Underfeed	Underfeed	Underfeed	Underfeed	Underfeed	Underfeed	Underfeed
Retorts	14	14	14	14	15	15	15	15
Tuyeres	23	27	29	39	45	45	69	69
Proj.grate area	380	380	380	427	524	524	694	694
Forced Draft Fans								
Number	2	3	2	8	4	4		
Make	Sturtevant	Sturtevant	Sturtevant	Green	Sturtevant	Sturtevant		
Type	Double inlet	Double inlet	Double inlet	Double inlet	Double inlet	Double inlet		
Static Head in.H_2O	?	?	?	13	8.5	8.5		
Capacity	170,000	170,000	170,000	60,000	120,000	120,000		
Control	Ward Leonard	Ward Leonard	Ward Leonard	Ind.Motor	Vane	Vane		
Induced Draft Fans								
Number	-			8	8	8	8	8
Make				Green	Sturtevant	Sturtevant	Sturtevant	Sturtevant
Type				Single inlet	Double inlet	Double inlet	Double inlet	Double inlet
Static Head in H_2O				8.3	15.5	15.5	19.0	19.0
Capacity c.f.m.				72,700	120,000	120,000	155,000	155,000
Control				Wound rotor induction Motor	Vane	Vane	Vane	Vane
Cinder Catcher								
Make	Murray	Murray	Murray	Green	Special			

by an automatic breaker of adequate rupturing capacity. For example, the outage of one feeder cable might take out one circulating pump, one hotwell pump and one generator fan or two induced draft fans each on separate boilers and one forced draft fan feeding into a common air duct for four boilers supplied by other fans. Thermal relays on each motor ring an alarm in case of overheating due to overload, low voltage or single phase operation. Most auxiliaries re-start automatically on restoration of voltage following a disturbance, unless the motor is deliberately tripped off the line.

Editor's Note: This is the third of a series of articles describing the New York Edison System. The concluding article discussing developments at East River Station will appear in a subsequent issue.

Comparison of Natural Gas Fuels

PART V. HEAT BALANCE AND COMPARATIVE EFFICIENCY. BY PALMER B. PLACE

EFFICIENCY of a heat absorbing piece of equipment is the ratio of the heat absorbed to the heat liberated. This may be determined directly by direct measurement or indirectly by measurement of the various heat losses and subtraction of their sum from 100. The latter method, known as the heat balance method, is of interest here in that the losses for various fuels may be calculated and the comparative efficiency with which the fuels may be burned can be predicted.

Losses that make up the combustion heat balance are:

1. Loss due to the sensible heat in the dry waste gases.
2. Loss due to incomplete combustion of the fuel.
3. Loss due to moisture in the fuel.
4. Loss due to moisture formed by the combustion of hydrogen.
5. Loss due to moisture in the air used for combustion.
6. Loss due to radiation.

Calculation of these losses may be found in any combustion handbook and will not be developed here. It may be pointed out, however, that for natural gas fuels the heat balance is particularly easy to obtain. The loss due to incomplete combustion will usually be zero with gas as fuel as no solid carbon loss occurs and, with good combustion, no carbon monoxide loss. With solid fuels this loss is frequently high and always difficult to obtain with accuracy. Also, the loss due to moisture in the fuel may be neglected in the case of gas fuels because the moisture is already in vapor form and the amount of heat required to superheat it to exit gas temperatures is small. Radiation losses from modern steam generating equipment may safely be estimated at 250 B.t.u. per sq. ft. per hour and in the absence of sufficient data for its calculation, the loss may be assumed to be one per cent of the heat in the fuel without serious error. The loss due to moisture in the air used for combustion is readily determined and normally is a minor item in the heat balance.

Major losses are the dry gas loss and the loss due to moisture formed by the combustion of the hydrogen in the fuel. The magnitude of these losses depends on the fuel analysis, on the amount of excess air, with which the fuel is burned and on the temperatures of the fuel, air, and exit gases. Assuming the same per cent of excess air, the same exit gas temperature and the same air and fuel temperatures, the sum of these two losses calculated for different natural gas fuels is a direct indicator of the relative efficiency with which these fuels may be used.

The amount of dry gases formed is a function of the combustible* carbon and hydrogen in the fuel and the amount of water vapor formed is a function of the hydrogen content alone. The sum of the losses may be expected to be a function of the combustible carbon-hydrogen ratio in the fuel and therefore the expected efficiencies may be expected to be a similar function.

TABLE I. ANALYSIS AND CHARACTERISTICS OF SELECTED NATURAL GASES

Sample No.	Per cent by Volume CH_4	C_2H_6	C_3H_8	B.t.u. /lb.	Lb. per lb. or fuel Dry Gases	Moisture	Ratio* C / H
1	98.5	-	-	23466	15.60	2.20	2.98
2	91.3	4.5	-	21956	15.30	2.04	3.07
3	84.7	9.4	4.3	22793	15.40	2.07	3.24
4	80.5	18.5	-	23077	15.55	2.08	3.26
5	73.2	25.6	-	22802	15.45	2.03	3.35
6	77.5	16.0	-	20057	13.65	1.82	3.24
7	50.6	10.9	-	12000	8.60	1.09	3.24
8	59.1	14.5	-	12767	9.10	1.15	3.28
9	32.2	67.0	-	22053	15.35	1.88	3.75
10	-	31.8	67.7	21860	14.95	1.67	4.37

*lb. combustible carbon over lb. combustible hydrogen.

In Table I, the analysis, heating value, combustion characteristics and carbon-hydrogen ratios are given for the ten natural gases selected for comparison.

In Table II, the calculated dry gas and hydrogen losses are given, arranged in order of increasing carbon-hydrogen ratios. Values for several hydrocarbons of the paraffin series are included to show the trend for increasing carbon-hydrogen ratios. The losses are calculated for zero per cent excess air, 500-deg. exit gas temperature, and 100-deg. fuel and air temperature. The calculation of these losses is illustrated in the following example:

Sample No. 1

Dry Gas Loss

$$\frac{15.60 \times .242 \times (500 - 100)}{23{,}466} = 6.44\%$$

Hydrogen Loss

$$\frac{2.20 \times [1050 + 0.47 \quad (500 - 100)]}{23{,}466} = 11.60\%$$

Total Loss.....18.04%

The results are plotted in Fig. 1. It is seen that the dry gas loss increases slightly with an increasing carbon-hydrogen ratio while the hydrogen loss decreases rapidly

*See Article II, page 447, April 15, 1931, issue.

TABLE II. RELATION BETWEEN MAJOR HEAT LOSSES AND CARBON-HYDROGEN RATIOS

Sample No.	C / H Ratio	Per cent Dry Gas Loss	Per cent Hydrogen Loss	Per cent Total Losses
1	2.98	6.44	11.60	18.04
CH_4	3.00	6.50	11.65	18.15
2	3.07	6.75	11.50	18.25
7	3.24	6.92	11.25	18.17
3	3.24	6.55	11.25	17.80
6	3.24	6.58	11.20	17.78
4	3.26	6.62	11.15	17.76
8	3.28	6.90	11.15	18.05
5	3.35	6.56	11.00	17.56
9	3.75	6.73	10.55	17.28
C_2H_6	4.00	6.67	10.00	16.67
10	4.37	6.62	9.45	16.07
C_3H_8	4.50	6.71	9.33	16.04
C_4H_{10}	4.80	6.80	9.05	15.85
C_5H_{12}	5.00	6.77	8.78	15.55

Calculated for 0 per cent excess air, 500 deg. F. exit gas temperature and 100 deg. F. fuel and air temperature.

with increasing ratio. The sum of the losses also decreases with increasing ratio. The actual difference in efficiency, however, for the wide variation in natural gases represented in Table I is less than two per cent and for most gases the variation would be less than one per cent. It should be understood that the above calculations do not mean that if two different gases are used in the same furnace that the overall efficiencies obtained will be within one per cent of each other. If, however, the furnace and boiler are designed in each case so as to give the same exit gas temperature when the fuels are burned with the same amount of excess air, then the overall efficiencies will be nearly alike.

Solid fuels have a much higher carbon-hydrogen ratio. The hydrogen loss for coal is of less importance than the dry gas loss. It is often claimed, and rightly

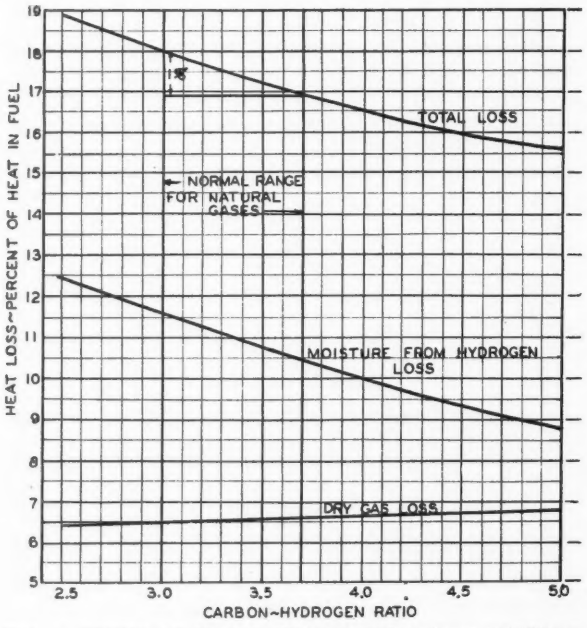


FIG. 1. TREND OF MAJOR HEAT LOSSES WITH INCREASING CARBON-HYDROGEN RATIOS

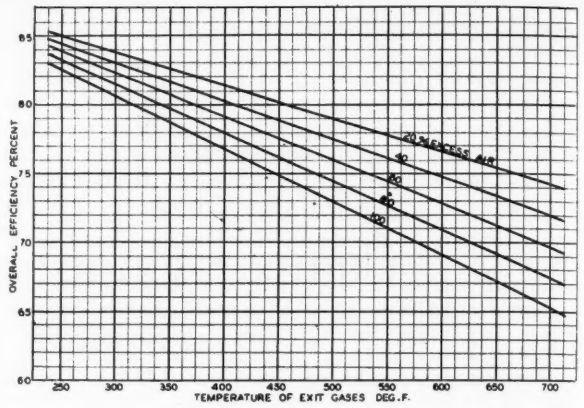


FIG. 2. OVERALL EFFICIENCIES—NATURAL GAS FUELS

enough, that the fuel efficiency for coal should be higher than for natural gases because of this difference in the hydrogen loss. The loss for a natural gas fuel may run 6 to 8 per cent greater than for coal burned under similar conditions. It is not so often pointed out, however, that the combined moisture in the fuel loss and unburned carbon in the refuse loss for solid fuels, often more than counterbalances their advantage in respect to the hydrogen loss and at the same time solid fuels are more difficult to burn and are subject to ash handling drawbacks.

Actual overall efficiencies that may be expected with modern steam generating equipment have been estimated for various conditions of excess air and exit gas temperature and are plotted in Fig. 2.

Temperature of the exit gases is the most important factor affecting the overall efficiency. A difference of 100 deg. F. in this temperature is equivalent to about 3 per cent in efficiency. The next factor in importance is the amount of excess air. A change of 20 per cent in the amount of excess air is equivalent to about 1 per cent efficiency at low exit gas temperatures and to about 2 per cent efficiency at high exit gas temperatures.

The values in Fig. 2, of course, will not apply exactly to all natural gas fuels but the variation in expected efficiency will not exceed plus or minus 1 per cent. The present practical limit of overall efficiency for natural gas fired steam generating units is about 85 per cent.

The Power Behind New York

WE DESIRE TO direct attention to several errors in Part II of the article "The Power Behind New York" which appeared on p. 702 of the July 1 issue. On page 703, the next to the last paragraph in the second column refers to Fig. 3 when, as a matter of fact, the description fits Fig. 5. Also, on page 704, first column, second paragraph, the description fits Fig. 3 and not Fig. 5 as stated. These errors occurred because the two curves Fig. 3 and Fig. 5 were unintentionally transposed in the make-up of the article. The caption Fig. 3 refers to the cut above caption Fig. 5 and vice versa.

On page 705, second column, a reference is made to Fig. 5 when it should have referred to Fig. 7. Also, on page 706, first column, ninth line, the word "output" should read "input."

Control of Electrical Equipment *in* Industrial Plants

Part III

by E. H. Stivender

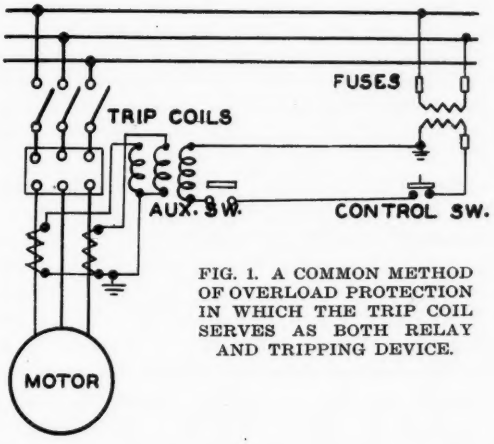


FIG. 1. A COMMON METHOD OF OVERLOAD PROTECTION IN WHICH THE TRIP COIL SERVES AS BOTH RELAY AND TRIPPING DEVICE.

TRIPPING DEVICES for circuit breakers are either of the series or shunt types. Series trip circuits are those in which the trip coil is operated in series with the line or from the second series of current transformers. Since operation of the trip coils depends upon current flowing in the line, this principle is in most cases preferable to that of a.c. shunt trip coils, for use in connection with protective relays. When a sudden or gradual decrease of impedance in a protected circuit occurs, the current increases while the voltage between lines usually decreases. For this reason, from the standpoint of reliability the series overload protection circuit is superior to that of the alternating current shunt trip circuit.

A general form of series trip circuit is shown in Fig. 1. The trip coils operate plungers which act directly on the circuit breaker mechanism. Oil dashpots are generally provided for the time elements of protective schemes of this type. Since the coils operate only when an overload occurs, an independent trip circuit must be provided in cases where the circuit breaker is operated by remote control. This is often accomplished by means of a shunt trip coil operating on the same lever as the series coils.

Series trip circuits as described above are not desirable where critical settings are necessary. As explained in the foregoing article dashpots containing oil will give time variations during temperature changes. Also, owing to the relay element being mounted on the circuit breaker mechanism, it cannot have close adjustments due to mechanical jarring and inaccessibility; therefore this practice is usually preferable only where economy is a ruling factor.

At voltages above 440 and normal operating currents above 50 amp., it is advantageous to use current transformers.

In alternating current circuits, relays and ammeters cannot be satisfactorily operated from shunts, because such instruments are always of higher inductance than shunts, hence a relay cannot be dependable nor be set for a given overload current. Also since shunts operate on the principle of voltage drop due to resistance only, and relays contain more inductive reactance than resistance, temperature changes will affect the accuracy. Even though the shunt were made of the same L/R value as the relay, temperature changes will cause an error.

Potential transformers are used on voltages above 440, as it is undesirable to bring high voltages to the switchboard due to hazards and the added expense of insulation which would be required in the control circuit.

Figure 2 illustrates a series trip circuit employing standard switchboard relays, allowing the relays to be mounted in an accessible position at the circuit breaker or elsewhere. The trip coils are normally shunted by contacts of the overload relays. When current conditions of abnormal value occur, the trip coils are placed in circuit by the opening of the contacts, thereby opening the circuit breaker. The relay contacts are generally arranged so as to snap open when operated, they may be hand reset or self-reset by the weight of the plunger on dropping back in place.

This scheme offers the desirable feature of incor-

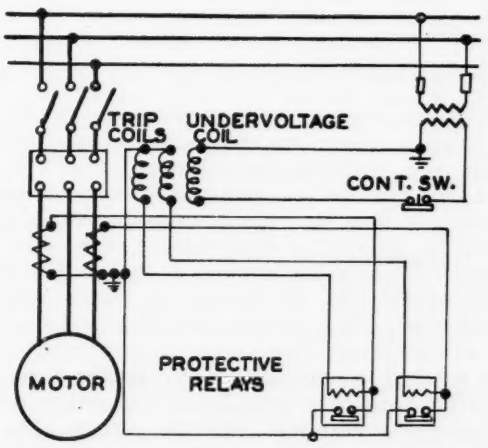


FIG. 2. A PROTECTIVE SCHEME IN WHICH THE SERIES TRIP COILS ARE SHUNTED BY OVERLOAD RELAY CONTACTS UNTIL ABNORMAL CURRENT CONDITIONS OCCUR

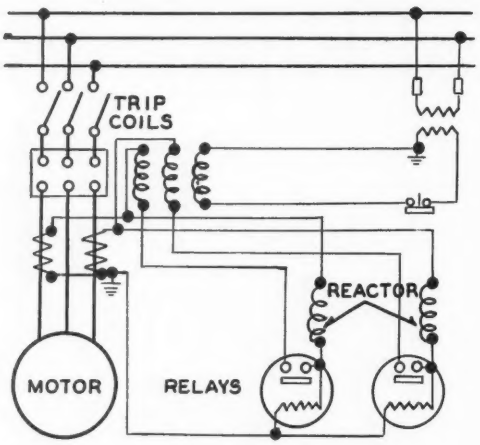


FIG. 3. THE TRIP COILS ARE OPEN CIRCUITED UNTIL AN OVERLOAD OCCURS. POTENTIAL DROP ACROSS TRIPPING REACTORS FURNISHES OPERATING VOLTAGE WHEN THE RELAY CONTACTS CLOSE

porating dependable operation with accessibility and the use of very sensitive relays. It is much used in installations where a direct current control source from storage batteries is not available.

In Fig. 3 is shown a series trip circuit employing tripping reactors. Small reactors are normally in series with standard overload relay coils. When sufficient current flows to close the relay contacts an abnormally high voltage drop occurs across the reactor terminals, the contacts close the trip coil circuits in such a manner as to utilize this voltage to trip the circuit breaker. Since it is sometimes preferable to use standard circuit-closing overload relays in connection with a circuit breaker equipped with a.c. shunt trip coils, this system has advantages over that of Fig. 2. Trip coils designed for series operation may be also used in this circuit.

The trip circuits illustrated in Figs. 1, 2 and 3 show only two current transformers for a three phase motor. If the power source is a grounded neutral system, it is of course necessary to provide three current transformers with three relays and trip coils in order to protect against dangers of short circuits to ground on all phases.

Instrument Transformer Secondary Circuits

Whenever certain relays operate in series with meters or other relays from a common group of current transformers, sufficient test terminals should be provided in order that one group of instruments can be disconnected from the current circuit without disturbing another group, that is when three relays, and three ammeters are operated in series as in Fig. 4, a means should be provided for testing the relays while the ammeters are left in circuit, since it is undesirable to take all instruments from service in cases where a motor is required to run continuously. In Fig. 4, arrangements for testing are provided by removable links in the current transformer and trip circuits. In this manner adequate facilities for testing are obtained. When it is desired to test the relays or ammeters independently, terminals corresponding to the desired circuit can be short-circuited and that particular circuit isolated without disturbing the wiring. Since it is important that the trip circuit be isolated from relays while testing is being done, easily accessible terminals should be placed for this purpose.

In many cases, it is not considered advantageous to complicate the current transformer circuits by the installation of more than one set of terminals for each set of transformers; however, it is generally more desirable to have efficient testing facilities than to disturb the switchboard wiring when the occasion for testing arises.

Current test terminals may be provided in the form of test blocks manufactured for such purposes, or they may consist of small switches or individual terminals with links. Testing switches, or calibrating switches are manufactured for use on the rear of the panel, while test blocks and terminals are made of suitable appearance and with sufficiently long studs for mounting on the front of the panel with all wiring on the rear.

Where it is not desirable to provide three ammeters for reading the current in a three-phase circuit but to provide an ammeter switch to connect one ammeter to any phase, it is imperative in some circuits, such as differential protective systems, that the resistance of the current transformer circuits shall not be changed by faulty contacts in the switch. It is generally preferable to provide separate current transformers for the differential relays, even though there is no ammeter switch in the circuit. In the case of three-phase motors, the load is normally balanced and only one ammeter is necessary; in cases of three-phase circuits furnishing individual single-phase loads, it is often desirable to use ammeter switches.

Use of a common ground wire for current and potential transformers is not always permissible, but is made in some cases. It is generally preferable to isolate the current and potential transformer secondaries completely, grounding each secondary independently. In cases where only two current transformers are used as in Fig. 2, the ground wire carries the same value of current as the other two wires.

When the current and potential transformers are

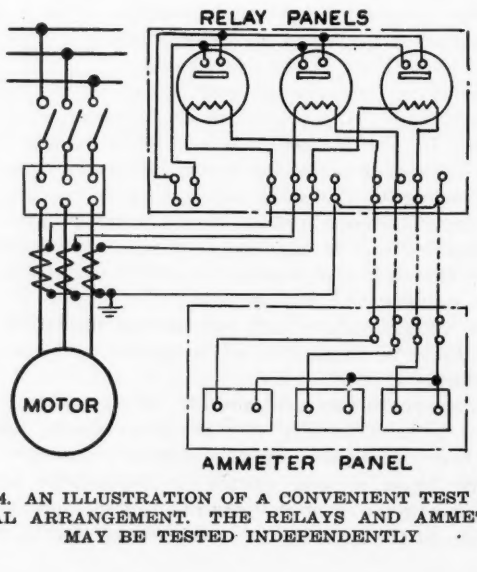


FIG. 4. AN ILLUSTRATION OF A CONVENIENT TEST TERMINAL ARRANGEMENT. THE RELAYS AND AMMETERS MAY BE TESTED INDEPENDENTLY

mounted adjacent, it is sometimes considered economical to eliminate one wire by connecting the ground wire of the potential transformers to that of the current transformers, thus requiring only five wires to the switchboard. In a general circuit such as Fig. 5 this is permissible but the connections should be arranged in such a manner that any one who has occasion to disconnect the potential ground at the switchboard will not accidentally open-circuit the current transformer secondaries, as would be the case if the common grounded wire were connected to the potential terminal. Links or switches are nearly always provided at the switchboard for entrance of current transformer secondary leads and the chances of opening the potential transformer circuit is small. Where undervoltage relays are operated from a circuit of this kind, however, it is nearly always preferable to run separate ground wire for current potential transformers.

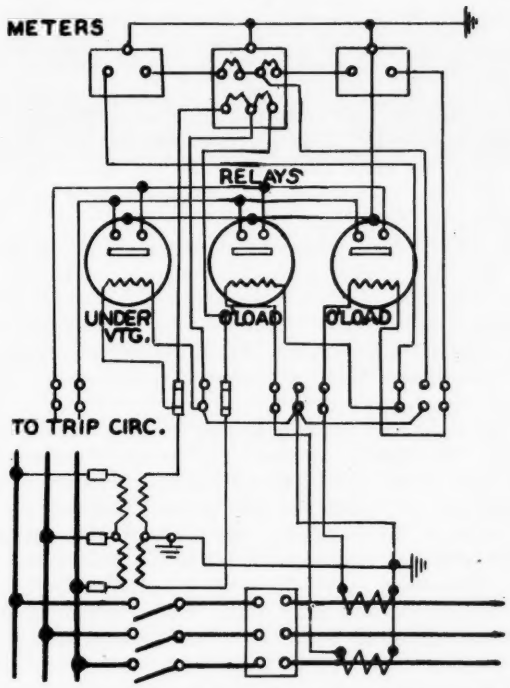


FIG. 5. A GENERAL CURRENT AND POTENTIAL TRANSFORMER SECONDARY CIRCUIT

Wherever possible, it is desirable to connect the undervoltage relays independently of other equipment in a potential circuit, that is, no fuses should be in the undervoltage relay circuit, but in order to decrease danger of injury to the potential transformers in case of short circuit fuses should be in the circuits of all other apparatus which do not depend upon low voltage for tripping the circuit breaker. A blown fuse or a loose connection in the undervoltage relay circuit will sometimes cause unnecessary tripping of the circuit breaker. If suitable low capacity fuses are not provided for other apparatus, a short circuit in this equipment will often cause sufficient drop to allow an undervoltage relay to close its contacts.

Grounding of instrument transformer secondaries is a necessary precaution against the appearance of any higher voltage in the instrument circuit. Fuses, where allowable, in the primary and secondary leads of potential transformers are desirable in nearly all cases. The grounding of potential transformer secondaries should be such that the potential between any other lead and ground will be the same; that is, one end of each single-phase winding should be grounded. No fuses should be placed in the grounded wire; hence, when a fuse blows in any other lead, it can easily be found in which phase the short circuit exists.

Since nearly all current and potential transformers are connected either in Y or open delta, a point common to all phase windings is obtainable for grounding.

An important factor in the design and operation of contact circuits is the question of indicating lamp and alarm arrangements. This will be discussed in a subsequent article.

A. S. T. M. Meeting at Chicago

FOR THE SECOND time in thirty years the American Society for Testing Materials held its Annual Meeting in the Middle West. The enthusiasm which the annual meeting was accorded is ample evidence of the interest shown in the Middle West in the aims and purposes of this national technical society.

The meeting at Chicago, which ended last Friday, June 26, broke all previous records. About 1500 registered and attended the sessions. This is 400 more than the previous high and does not include approximately 150 exhibitors who participated in the first A. S. T. M. Exhibit of Testing Apparatus and Machines.

Several outstanding sessions deserve special mention. The Symposium on the Effect of Temperature on the Properties of Metals was probably the high light of the meeting. Over 500 were in attendance at the afternoon and evening sessions and from the new and valuable data presented, it was apparent that the subject was one in which great interest has been shown and which will continue to press to the fore where high and low temperatures influence the design and use of engineering materials.

An innovation of these sessions was the fact that no papers were presented by the authors, but the papers in the two sessions were summarized as previously announced in Power Plant Engineering, by L. W. Spring, Chief Chemist, Crane Co., Chicago, and H. J. French, Metallurgical Engineer, International Nickel Co., respectively. This procedure provided the time necessary for the presentation of discussion which contributed greatly to the present knowledge on the properties of materials at high and low temperatures.

A joint session with the Western Society of Engineers featured the Eleventh Session, Thursday evening. The Economic Significance of Specifications for Materials was forcefully brought out in this session. Several executives and engineers gave addresses and the general concensus of the session was that while great progress has been made in specification writing by such societies as the A.S.T.M. and other national societies, there is much more to be done, and the sooner it is done, the greater will be the saving in construction and manufacturing costs.

Exhibit of Testing Apparatus and Machines, held for the first time in conjunction with an annual meeting of the Society, gave the members of the Society and the testing fraternity in general a composite picture of the great number of instruments available for testing.

A Vacuum Tube Voltage Regulator*

A device has been developed which not only provides voltage regulation for alternators, but short circuit protection as well. Saturation current from the filament of a thermionic tube forms the control element, while stabilization is accomplished by a feed back system.

By
L. C. VERMAN
and
L. A. RICHARDS
both of
Cornell University
Ithaca, N. Y.

VACUUM TUBES HAVE been suggested for use as voltage regulators for several years and while they have been so used in certain instances, their application has been limited to generators of small size. Few attempts have been made to adapt such means of regulation to meet the needs of large power units.

Recently, however, a regulator of this type was developed by the physics department of Cornell University and has been in use for about two years in the laboratory on a 25-kw., 100-v. d.c. generator. This regulator has required no readjustment or replacement of parts.

Encouraged by this performance, a similar voltage regulator has been developed for use on alternators. Operation of this regulator involves conversion of a.c. line-voltage fluctuations into corresponding d.c. variations, amplifying these and applying them to the field of an exciter which supplies the main alternator field, thus controlling the line voltage.

A schematic diagram of the regulator circuit is shown in Fig. 1. As may be noted, the amplifying system is the ordinary resistance coupled type. All the grid bias and plate voltages are supplied by a single B-eliminator system operated from the alternator being regulated. Tube filaments are lighted directly by alternating current through individual transformers also supplied from the generator under regulation.

The first tube (in this case a UX-210 type) is operated at a low filament temperature and high plate voltage, so as to obtain saturated plate current. Under these conditions, the current through the coupling resistance R_2 is nearly independent of the plate voltage, but changes rapidly with the filament temperature and hence with the r.m.s. value of the line voltage. This scheme was found to be inferior to a grid-control method since the grid potential must be obtained from the B-eliminator output voltage which is more closely related to the average rather than the r.m.s. value of the line voltage.

Voltage drop across R_2 is balanced out by a small adjustable portion of the eliminator output and is then applied to the grid of the second tube—a high μ, UX-240 type. Thus a decrease in the line voltage makes the grid of the second tube more negative, cutting down the current through R_3, which makes the grid of the last tube more positive thereby building up its plate current. This increases the exciter voltage, builds up the main alternator field and boosts the line voltage. An increase in line voltage simply reverses this process.

A UX-210 type tube is employed in the last stage of the amplifier to supply the field current to the exciter generator whose field is wound to match the d.c. plate resistance of the tube. This field winding is the only special piece of apparatus used in the entire system, all the other parts being of standard make and readily obtainable.

Since the vacuum-tube system is almost instantaneous in its response to small fluctuations, the original regulator with the high amplification required for regulating a.c. machines was rather unstable in its operation. This condition, together with the comparatively long-time lags in the fields of the exciter and the main alternator, caused hunting, *i. e.*, oscillation of the line voltage about a mean value. After a good deal of experimentation it was found that the regulator could

*From a paper presented in the June issue of Electrical Engineering.

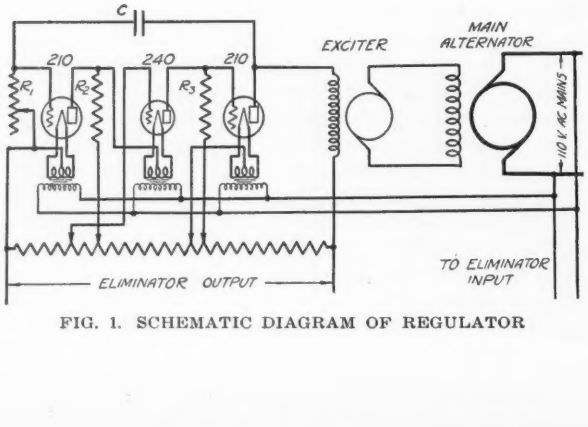


FIG. 1. SCHEMATIC DIAGRAM OF REGULATOR

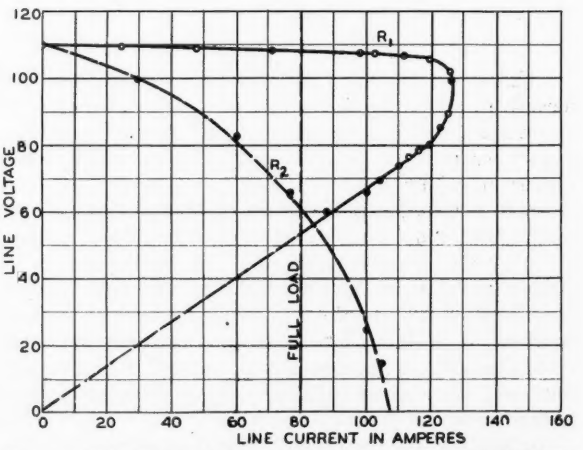


FIG. 2. VOLTAGE CHARACTERISTICS OF AN ALTERNATOR WITH UNITY POWER FACTOR LOAD; R_1, WITH VACUUM TUBE CONTROL. R_2, FIXED EXCITATION WITHOUT REGULATOR

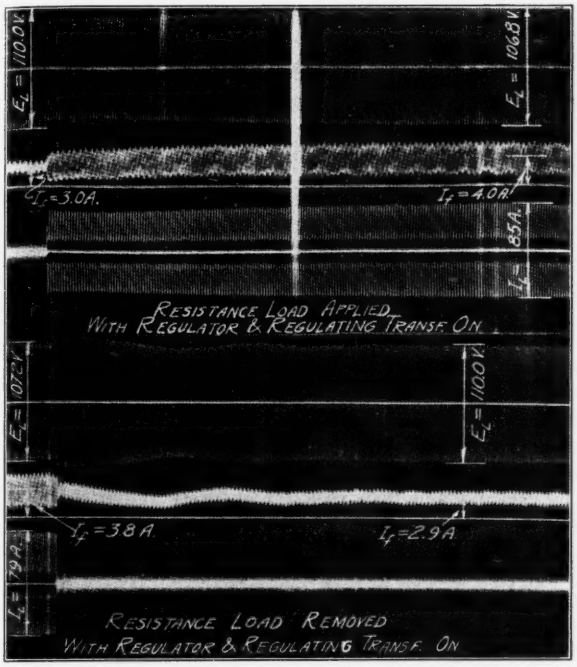


FIG. 3. ALTERNATOR TERMINAL VOLTAGE, AND FIELD AND LOAD CURRENTS WITH REGULATOR AND REGULATING TRANSFORMER IN USE; (ABOVE) FULL LOAD IS SUDDENLY APPLIED; (BELOW) THE LOAD IS CUT OFF

be stabilized by a feed-back coupling system composed of a condenser C and a resistance R_1, which reacts on the grid of the first tube. This virtually delays the response of the regulator, thus cutting down its tendency to over-correct.

A number of experiments was made with this regulator connected to a 35-kv-a., 220-v., two-phase alternator, operated as a single phase machine at 110 v.—this being the rated voltage of the eliminator equipment. This constituted a severe test for the regulator, because for a given load the field-current correction necessary to maintain constant voltage is greater for low than for high voltages.

The characteristics of terminal voltage with load current at unity power factor, with and without the regulator, are given in Fig. 2. It may be noted that at full load with the regulator, the terminal voltage drops only 1.5 v. as compared with a 50-v. drop with fixed excitation.

Oscillograms (see Fig. 3) were made showing the line voltage, line current, and field current when full load at unity power factor was suddenly applied and then suddenly dropped with the regulator in operation. In these tests a regulating transformer was used to supply the B-eliminator of the regulator. This transformer was developed especially to maintain constant output voltage for a wide range of primary voltages, the load remaining constant.

With the regulating transformer in use, however, an added load of 15 amp. at a low power factor was imposed upon the alternator, consequently the *percentage* regulation was not quite so good as when the transformer was not in use.

Referring again to curve R_1, Fig. 2, it may be noticed that at about 50 per cent overload the voltage starts to decrease rapidly. This is due to the fact that the B-eliminator output and the temperature of the first stage tube filament drop sufficiently to make further regulation impossible. After the point of maximum current is reached, the system becomes unstable and the voltage drops rapidly back to zero, thus providing overload protection for the generator. The amount of overload at which the relay action starts depends upon the regulation characteristics of the eliminator as well as upon the average operating temperature of the first tube filament.

An oscillograph record showing the transient conditions occurring at short circuit with the regulator and regulating transformer in operation, is presented in Fig. 4. As may be seen, the short circuit is reduced to full load value in about 0.6 sec.

Field Current

It is shown also in Figs. 3 and 4 that the field current of the alternator is not a steady direct current but has superimposed upon it a strong 120-cycle current. This comes from two sources: First, since the filaments of the tubes are lighted directly from the alternator, plate currents of all tubes contain a 120-cycle component which is carried right through the exciter to the main field. Second, the single-phase, 60-cycle current flowing through the windings of the armature of the main alternator induces in its field a 120-cycle e.m.f.

This 120-cycle component in the field current is of advantage, however, since the magnetic circuits of the exciter as well as the alternator are continuously carried around a hysteresis loop, thus making the average magnetic flux, and hence the generated voltage, always a single valued function of the d.c. component through the field. This field current ripple, being an even harmonic, causes no distortion in the wave force of the output voltage.

Further Probabilities

This regulator furnishes an indication of what may be accomplished by means of a vacuum tube control for power equipment. It is evident that the design might be varied to accomplish purposes other than the simple control of a single phase machine. For example, compensation for line voltage drop could be introduced by means of an extra winding in the filament transformer of the first tube, this winding having all or a part of the line current flowing through it. In case of polyphase alternators, a variety of schemes could be used for arranging the transformer or transformers, supplying the control filament, depending upon what system voltage it is desired to control.

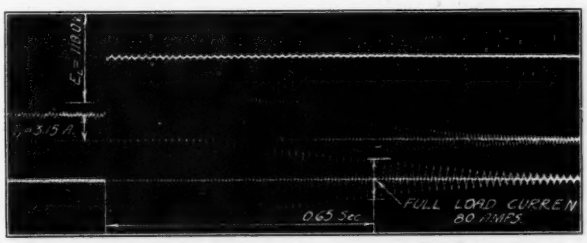


FIG. 4. ALTERNATOR VOLTAGE AND CURRENT RELATION AT TIME OF SHORT CIRCUIT. NOTE THAT FIELD CURRENT IS RAPIDLY REDUCED TO A NEGLIGIBLE VALUE BY THE PROTECTIVE ACTION OF THE VACUUM TUBE REGULATOR

Safe Harbor Kaplan Units Develop 255,000 Hp.

INITIAL INSTALLATION AT THE NEW HYDROELECTRIC DEVELOPMENT ON THE SUSQUEHANNA RIVER, PLANNED FOR ULTIMATE CAPACITY OF 500,000 HP., NOW UNDER CONSTRUCTION BY SAFE HARBOR WATER POWER CORP.

AT SAFE HARBOR, Pa., on the Susquehanna River about 37 mi. south of Harrisburg, the Safe Harbor Water Power Corp. is constructing one of the largest hydroelectric projects in the country, designed for an

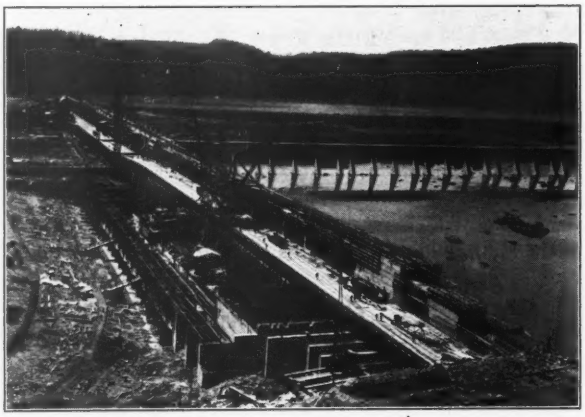


FIG. 1. RECENT VIEW OF SAFE HARBOR DEVELOPMENT UNDER CONSTRUCTION ON SUSQUEHANNA RIVER

initial capacity of about 255,000 hp. in six Kaplan waterwheel generator units and planned for an ultimate capacity of over 500,000 hp. The Safe Harbor Water Power Corp. was formed for building this project by the Pennsylvania Water & Power Co. which owns and operates the Holtwood hydroelectric development, 8 miles below Safe Harbor on the Susquehanna and by the Consolidated Gas, Electric Light & Power Co. of Baltimore. Holtwood and Safe Harbor are to be operated as a single development. J. E. Aldred is chairman of the board of all three companies. The Safe Harbor Corp. is carrying out the engineering design of the Safe Harbor project. It is being erected by the Arundel Corp.

In this project, the dam and power house together are nearly a mile long. The dam consists of two overflow or spillway sections with an intermediate bulkhead or non-overflow section on an island in the middle of the river. Steel gates on these overflow sections, operated by two traveling gantry cranes, will control the flow of water and will have a combined capacity of 970,000 cu. ft. per sec. or one-third greater than the largest recorded flow at this point. General construction features of the Safe Harbor plant include excavation of over 1,000,000 cu. yd. of rock, placing of 460,000 cu. yd. of concrete, erection of 18,000 t. of structural steel, 5500 t. of reënforcing steel, and laying of 23 mi. of temporary railroad track. About 8½ mi. of track of the Columbia & Port Deposit railroad are to be raised several feet and the railroad bridge across the mouth of Conestoga Creek is to be raised 4½ ft.

For concrete forms, cofferdam cribs, trestles and buildings, about 20,000,000 board feet of lumber will be consumed on the project. The total labor hours are estimated at about 14,000,000 man-hr.

All work is carried on from the Lancaster County side of the river with yard facilities on the flats of Conestoga Creek which flows into the Susquehanna at this point. Machine shops, carpenter shops and large warehouses adjoin this yard and storage facilities have been provided for about 40,000 t. of sand. Limestone for the rock fill and trap rock for concrete aggregate have been quarried a half mile east of the storage yard and in the valley between the quarry and the yard, crusher plant and storage facilities for crushed rock have been located. To bring all these materials from the yard to the dam site, a railroad bridge has been built across Conestoga Creek. This bridge later will be a permanent connection to the power house.

Besides these facilities for handling material, quarters for workmen have to be provided together with the necessary offices and a water supply system for the construction area. A 33-kv. transmission line connects the construction site with the Holtwood power house.

In the power house will be installed the first six generating units of the installation. The waterwheels are Kaplan turbines each with a rated capacity of 42,500 hp. at 55 ft. gross head. Three of the turbines are of S. Morgan Smith Co. manufacture and three are made by I. P. Morris & DeLaVergne, Inc., but all will be of the same design so that most of the parts will

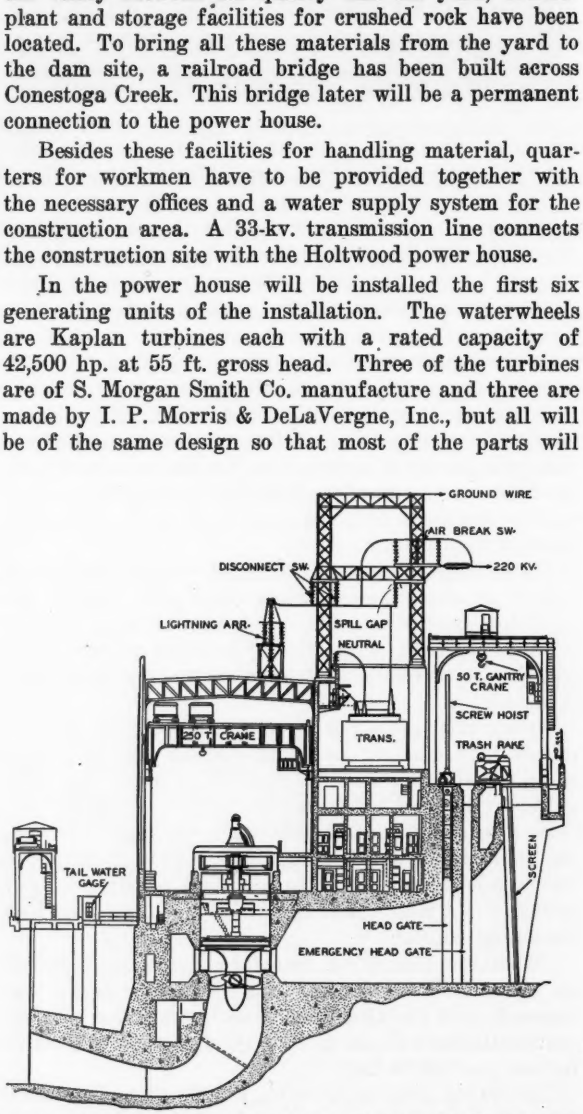


FIG. 2. CROSS SECTION THROUGH SAFE HARBOR POWER HOUSE

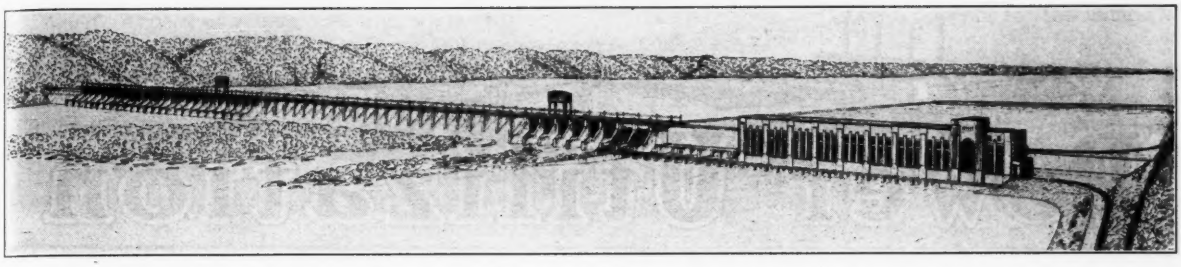


FIG. 3. SAFE HARBOR DEVELOPMENT AS IT IS EXPECTED TO APPEAR WHEN COMPLETED

be interchangeable. Water passages from intake at racks to discharge of draft tubes are also of the same design. This unusual arrangement was made possible by the coöperation of the engineers of the manufacturers and the power company and as the result of research work carried out by the engineers at the manufacturers' laboratories and at the new hydraulic testing laboratory erected by the Aldred interests at Holtwood.

This laboratory at Holtwood was designed for testing model turbines and settings under full head and made it possible to design a setting for the Safe Harbor units which, it is hoped, will practically eliminate the effect of cavitation.

The solid concrete gravity dam will be 4080 ft. long, of which 1810 ft. forms the spillway section. The crest gates are of the Stoney type, 48 ft. wide and 35 ft. high, including a 3 ft. freeboard at the ultimate pond elevation. The reservoir created by this dam extends up river 10 mi. and has an area at elevation 225 of 10.4 sq. mi.

The power house is integral with the dam on the east side of the river and is about 920 ft. long. The substructure is of monolithic concrete and the superstructure of steel and brick.

The generators driven by the above waterwheels are four G. E. and two Westinghouse 13,800-v., 28,000-kw. machines, operating at 109.1 r.p.m. On these units, the thrust bearing is below the generator. For station service, two 3100-hp. water wheels will drive 2500-kv-a. 70 per cent power factor, 60-cycle, 460-v. generators with a direct-connected exciter.

Direct connected main and pilot exciters on each main generator will provide quick response excitation for each machine but there will be no parallel operation of exciters. An emergency excitation transfer bus will be provided so that a spare motor-driven 200-kw. exciter may be substituted for anyone of the direct-connected exciters.

Main power transformers will consist of two 84,000-kv-a. self-cooled 126,000-kv-a. forced air cooled banks stepping the voltage up from 13,800 to 220,000. Each bank contains three General Electric single-phase units. There will be one spare.

For tying in with the existing 70-kv. Holtwood-Lancaster transmission line two 3-phase Westinghouse 30,000-kv-a. self-cooled or 45,000-kv-a. forced air cooled transformers will be used. These have load ratio control with range of 10 per cent each way.

Duplicate 13,800-v. buses for parallel operation of the main units and for supply of power to main and house service transformer are provided.

Total estimated cost of the initial development at Safe Harbor is about $30,000,000. This, of course, will include the power house foundation built for the ultimate installation and other items that can be used in the finished plant.

U. S. Chemists Study Soviet's Petroleum Progress

ORGANIZED STUDIES of Russia's quickening progress in petroleum research are being made by American petroleum chemists, according to Dr. C. D. Lowry, Jr., of Chicago, secretary of the Petroleum Division of the American Chemical Society, announcing that the Division will convene in Buffalo, August 30—September 4, in connection with the 82d meeting of the Society.

Stalin's economic policy, stressing the significance of petroleum, has succeeded in whipping up Soviet chemists, it is disclosed by Chemical Abstracts, the Society's reporting system, which, with Ohio State University as a center, is constantly combing the current scientific literatures of the world for developments of value to the chemists of the United States.

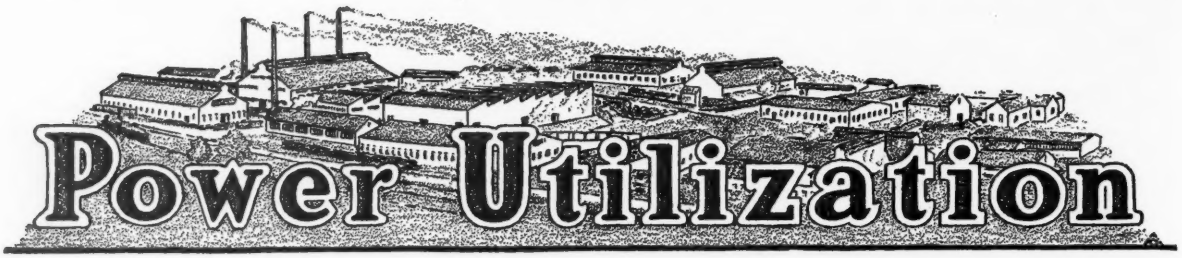
"The Division," said Dr. Lowry, a member of the technical staff of Universal Oil Products Co., "is circulating for its members important articles in petroleum technology in the Russian literature. Due to the emphasis on petroleum in the Soviet five-year plan, the number and importance of these has greatly increased of late."

Representatives of the nation's leading oil companies, Government bureaus, universities, and other organizations will participate in the Buffalo sessions of the Division, of which Dr. C. R. Wagner of Chicago, chief chemist of the Pure Oil Co., is chairman.

Among the events will be a joint symposium on Utilization of Gaseous Hydrocarbons with the Gas and Fuel Division, headed by Dr. G. St. J. Perrott of the U. S. Bureau of Mines, Pittsburgh, and the Division of Industrial and Engineering Chemistry, of which Dr. R. E. Wilson of Chicago, in charge of the Development and Patent Department of the Standard Oil Co. of Indiana, is chairman. Prof. D. B. Keyes of the University of Illinois will preside at the symposium.

"Utilization of gaseous hydrocarbons," the announcement said, "is of particular interest at this time because of the development of large natural gas pipe lines, some of them, such as the new line from the Texas Panhandle to Chicago, extending for more than 1000 mi.

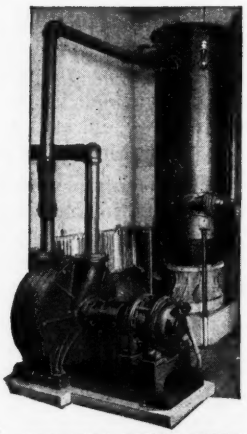
"Natural gas is now available in most of the large cities of the country. It has almost completely displaced manufactured gas on the West Coast, and it is proposed to supply it to the Eastern seaboard. This introduction of natural gas is notably affecting the fuel situation in many industries



Pneumatic Cleaning *for* Power Plants and Industries

By FRED W. LIEBERG

Portable Plants, Central Exhausters, Piping Systems, Dust Disposal



CENTRAL EXHAUSTER AND DUST TANK

NOT SO VERY long ago, it used to be said that the majority of manufacturers were using cleaning methods, which, when compared with the methods employed in their own homes, look like a page from ancient history. Even today some industrial plants cling to the old pan and broom method of stirring up dust in the

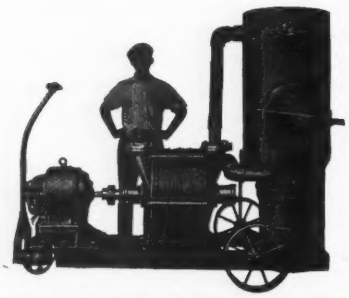


FIG. 1. PORTABLE MOTOR-DRIVEN SYSTEM

effort to remove and collect the periodic accumulations. Plant cleaning is a difficult subject to tackle in a general way because no two jobs are exactly alike and to that reason we may, perhaps, attribute the dearth of available information.

Pneumatic cleaning or vacuum cleaning is really pneumatic conveying. Just as bulk material is conveyed through pipe lines from certain stations to a central point, so in cleaning, dust and refuse are taken in at certain stations and delivered to a central point for disposal. That is one method but, by using a portable system with only hose lines instead of pipe lines, we can have the same operation and at lower initial cost, hence it is well to compare the merits of these two methods of pneumatic cleaning.

Portable Vs. Central System

Choice of the type of equipment best suited for a particular cleaning job should rest upon a thorough survey. For instance, the industry that usually works around the clock without shutdown will be ill advised to consider the portable equipment, except for some particular application. The portable machine might appear logical and adaptable but, because electric cable connections have to be made and because the cleaner's hose line must be manipulated through aisles around machines and benches, there is always the possibility of being in somebody's way with inevitable delays to the cleaner and to other workers. The portable cleaning equipment has its uses, especially for small power plants and in factory stock rooms. In some buildings a piping system could be put in only at great cost and here again the portable would be considered. The portable machine may have the same capacity for rapid work as the central system, so it is not necessarily a question of getting better results from one than from the other but the type of system can make a big difference.

When we speak of general cleaning, we usually refer to cleaning that will include picking up and conveying dirt, dust and refuse from floors, ledges and equipment; dust and film from walls, ducts, girders, pipes and machinery and loose material that will pass through the throat of the cleaning tool being used. Few pneumatic cleaning systems embody all the features necessary for such thorough cleaning.

Exhauster Types

Undoubtedly, the multi-stage centrifugal type of exhauster or vacuum producer with properly proportioned dust separation tank is the heart of the most favored type of system. Automatic power control effectively prevents waste of power, at intervals when the machine is in operation but no sweeping is being done. This type lends itself to either stationary or portable equipment. It combines easily-handled hose lines, moderate size piping when the central system is installed and the lowest maintenance expense. Another type of equipment includes the rotary exhauster. Then there is the steam aspirator system, which in some cases eliminates a collecting tank but includes hose and tool equipment similar to the other systems mentioned. Except where an abundance of steam can be spared in sufficient quantity to induce a velocity of air at the aspirator of not less than 5000 ft. per min. and a corresponding volume of air at the operator's cleaning tool of not less than 80 cu. ft. per min., the latter system may be considered a luxury. So it will be sufficient to confine ourselves to the requirements for the other two systems.

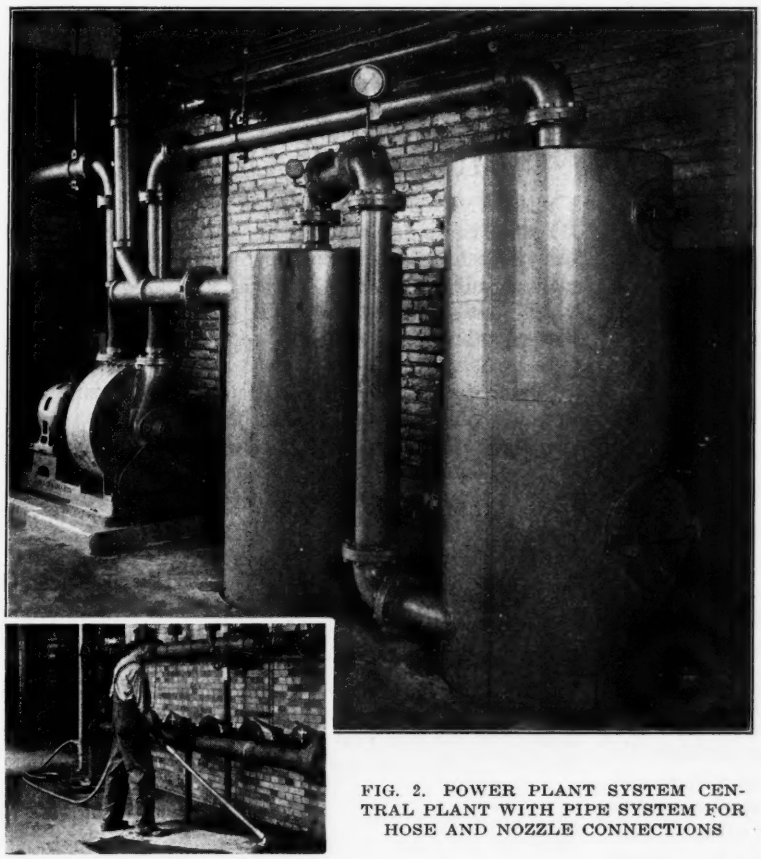


FIG. 2. POWER PLANT SYSTEM CENTRAL PLANT WITH PIPE SYSTEM FOR HOSE AND NOZZLE CONNECTIONS

Centrifugal and rotary type vacuum producers can be direct or belt driven. The centrifugal has the characteristic of variable volume with constant suction over a wide range of working conditions. The rotary has positive or constant volume (by relief valve governor) with varying suction. The former cannot build up excess suction nor can it handle over its rated volume of air with a given horsepower and speed. The latter, however, has a theoretical, if not practical, tendency to build up suction, to the limit, of course, of the setting of the popoff or relief valve. Action of this relief valve can be used to advantage perhaps in cleaning or breaking through a clogged pipe but present day efficiency makes such provision unnecessary.

Piping Sizes

Because piping sizes, hose sizes, cleaning tool areas and throat sizes have been so carefully studied through experimental work, it is known exactly what size vacuum producer and dust separating tank are necessary to handle a cleaning problem rapidly and thoroughly. It is generally conceded that for work which will give the cleaning operator a sense of mastery over his job, the 2-in. hose line and proportionate tools are most desirable. That is, the 2-in. equipment is most suitable for rapid work on operating floors or for work where a large area can be easily covered. For working around machinery, on overhead piping and rigging, on boiler tops and places hard to get at, the 1½-in. hose is preferable, with tools in proportion.

Number of cleaning operators who are to work simultaneously governs to a large extent, the size of the vacuum producer and dust separating tank but, in every case, it is necessary to consider the kind of dust and refuse most prevalent and upon that is based the velocity of air required at the cleaning tool, which can be economically produced for the system as a whole.

This question of the number of operators to work simultaneously is really quite important, as upon this rests the decision as between a portable or central system also what size system should be used. When speaking of the size of system, the number of sweepers to operate simultaneously is usually referred to. Sometimes a two-sweeper system may be referred to; sometimes a ten-sweeper may be spoken of; at other times a system is rated in horsepower. It is considered standard to allow 5 hp. per sweeper for heavy industrial work, although under certain conditions this can be and is varied, according to the piping involved in a stationary or central system and according to the length of hose which would be necessary in a portable outfit.

There is no best arrangement for any kind of pneu-

matic cleaning system. So many factors are involved that each problem must be considered separately but here is the way to start figuring. First of all, decide upon whether one man shall be responsible for cleaning your plant, making the rounds on a schedule and working according to accessibility and interruption involved (and this is possible mainly with the central or piped system, seldom with the portable system) or whether a crew of cleaners of two or more shall clean at given periods. In the former case, when practical, it will be found admirable to have one man responsible. He will take pride in his work and in his vacuum cleaning equipment. If it is decided that a crew shall do the cleaning, it is desirable to have one man take charge of the equipment and be responsible for the machine.

Decision having been made regarding the number of men to be cleaning simultaneously, it is not much of a job to choose whether a portable or a central system shall go in. Here a word of warning. Don't be stingy on the piping, if a central system is decided upon. A few more outlets and accompanying piping amounts to little in cash but, in rapid and thorough cleaning work, it means a whole lot. Try to arrange inlet service valves so that, for operating floors, 25-ft. lengths of hose will cover the area to that reached from the next inlet valve. Cleaners can do far better work with a length of hose that can be shifted from valve to valve to cover a radius of 25 to 30 ft. at each valve than by dragging a 50 or 60-ft. length of hose over a larger area.

Next in line, if the crew system for cleaning is decided upon, is how many operators would be handling 1½-in. hose on upper work and how many would be using 2-in. hose on lower work. If two will clean simultaneously using 2-in. hose line and tools, for a limited piping system we shall need a 10-hp. unit.

Another word of warning here. So long as we are on a sanitary dust collecting and removing job, insist on a separating tank with ample area and cloth filtration. Two types of separators are widely used in connection with pneumatic cleaning. The screen type permits a large quantity of dust to pass through the exhauster or vacuum producer and so to the atmosphere. With the filter type available, the screen method of dust separation should be frowned upon; for surely all the dust removed and conveyed should be collected. Where large quantities of dust are to be removed, a rotary discharging device sealed to the separating tank and working under vacuum may be added for the purpose of continuous dumping but this is necessary only on large systems where coal siftings or material to be reclaimed are to be handled.

For a dust separating tank made with a dumping gate, a sack is usually hooked to the hopper and the accumulated refuse dumped periodically. Another type, a sanitary method which is usual on up-to-date portable machines has a removable bucket. Still another type is the tank with cleanout doors, which necessitates removal of refuse by manual effort and involves the old shovel and wheelbarrow method.

Today pneumatic cleaning systems are far different from those formerly struggled with. There is practically nothing to go wrong, nothing to watch and, except for periodical lubrication of the machine and motor, there is little maintenance. Hose wears out, of course, and tools need replacement but the cost is insignificant when compared to the replacement of brushes and brooms. What is most important is a clean place to work in, which encourages the best kind of work and helps the best kind of worker to maintain higher standards, which is good business for everybody.

As to saving in time as between broom cleaning and pneumatic cleaning nothing can be said, because the human element and the results expected or desired, all play a part. It can be said, though, that no broom has ever satisfactorily kept film from spic and span paint on walls and girders, also no compressed air blowing system has ever decreased the cost of maintenance through reducing abrasion on machinery. Dust should be removed, not distributed. If money is to be spent to remove dust, let us remove it, once for all.

Rubber Belt Durability *

RECOGNIZING that separation of plies is not the only cause for removal of a belt from service, it was yet desired to determine the effect of various factors such as number of plies, tension per ply per inch of width, belt speed and pulley diameter on the length of time a rubber belt will run before adhesion between plies breaks down.

Tests were made at various unit belt tensions both running idle and transmitting power through a dynamometer, the conclusion being reached that the maximum unit tension is the important factor. Life was somewhat less when transmitting load than from the same unit tension of the belt when driving an idle pulley. For idle tests, the belts were run vertically, the driven pulley being below, mounted in vertical ways in a crosshead frame, which was weighted to give the desired tension.

Most samples were 3 in. wide but reducing tension to pounds per inch width per ply brought results to a common basis. One 6-ply belt was tested, but to get other ply thickness an 8-ply belt was used, taking off plies from the side next the pulleys to get the thickness desired. Tests were run until a separation of 5 in. along the belt took place as this was more easily determined than the exact moment when separation started. Joints were by plate and split rivet fasteners but separation was apparently not influenced by them as it occurred remote from a joint as often as near a joint.

Samples of 4, 5, 6, 7 and 8 plies were tested, on pulleys of 4, 6, 8 and 10 in. diameter, at tensions of 6, 9, 12, 15, 18 and 21 lb. per ply-inch and at belt speeds of 750, 1500 and 3000 ft. per min.

Results were embodied in a formula which, when plotted for various conditions, conformed closely to the results. It does not give a means of determining the life of a belt but indicates the relative effect of various factors on belt life.

In general, the hours running before a 5-in. separation of plies occurred increased with the 5.35 power of the diameter and became less with the square root of belt speed, with the 6.27 power of number of plies and with the 4.12 power of unit tension. Pulley diameter, number of plies and unit tension are, evidently, the most

*From a paper by E. G. Kimmich of Goodyear Tire & Rubber Co. presented before the American Society for Testing Materials.

important factors. Very high belt speed might have a greater relative effect due to centrifugal force tending to separate the plies.

The conclusion reached was that the belt user can add materially to the life of a rubber belt by using pulleys of good size, and thin belts of ample width to give moderate unit tension. Too thin a belt, however, will have a tendency to stretch.

To give a more concrete picture of the effect of various factors: For a 6-ply sample from the 8-ply belt, life was affected by pulley diameter as follows:

Hours run at 12 lb. per ply-inch.

Pully Diam. in.	4	5	6	7	8	9	10
Life in hrs.	15	30	60	140	290	540	900

Effect of unit tension on life was as follows:

Hours run on 6-in. pulley.

Pounds per ply-in.	6	9	12	15
Life in hrs.	1000	200	60	20

Effect of number of plies on belt life was:

Hours run on 6-in. pulley.

No. Plies	4	5	6	7	8
Life in hrs.	800	230	60	20	10

This is evidently affected by the fact that a 6-in. pulley is too small for an 8-ply belt but, even with a 10-in. pulley, the life for 8-ply was 160 hr. as compared with 930 hr. for a 6-ply.

Planer Drive by Two Motors

By James F. Hobart

TO OPERATE a 30-in. planer at some distance from a line shaft, a 5-hp. a.c. motor was rounded up in the shop and belted but proved too small to drive the planer when two boards were being run through. It worked all right when a single board was being planed.

Another a.c. motor of 4 hp. and of a different make was dug up by the foreman and we set about connecting this to the planer to drive in parallel with the first one.

Followed headshakings by the electrician when asked whether it could be done but the foreman went ahead and, after some experimenting, succeeded in driving the planer satisfactorily with the pair of motors pulling together. The plan followed was this:

On the back of the planer, a little above the floor was a built-in countershaft, B. This was moved over to permit placing a drive pulley on each end as in Fig. 1 at C and D. The motors were attached to the ceiling and the problem was to arrange pulley sizes so that both motors would drive the countershaft at exactly the same speed.

With motor speeds and required countershaft speed known, pulley sizes were calculated as closely as possible, making allowance for slowing down of each motor under load. The motor belted to C was then started, letting the other motor run idle, and countershaft speed was taken with a revolution counter. Then the second motor was used to drive, the first being idle, and countershaft speed again taken.

It was found that for both motors to drive the shaft at the same speed, pulley D must be increased slightly in diameter about ¼ in., which barred the use of a stock size pulley. To avoid ordering a special pulley, the millwright suggested "lapping" the present pulley and secured strips of felt, the same width as the pulley face and as long as possible. Burlap or other fabric might have been used, if felt had not been available.

Next some rosin was pounded to a powder, mixed with machine oil and heated until fully melted. It was tested by dropping a bit of the hot mixture into cold water, then smearing it on a bit of the felt, adding rosin until a most tenacious stickiness was secured.

Then this sticky wax was applied in spots close together along the length and continuously across the end to one side of a felt strip. This strip was carefully placed on the belt, sticky side up, next to pulley D, Fig. 2. The pulley was turned slowly by hand and the felt wound upon it smooth, being kept under a smart pull during the winding.

With this lagging in place, motors were again started alternately and speed of the countershaft tested. More

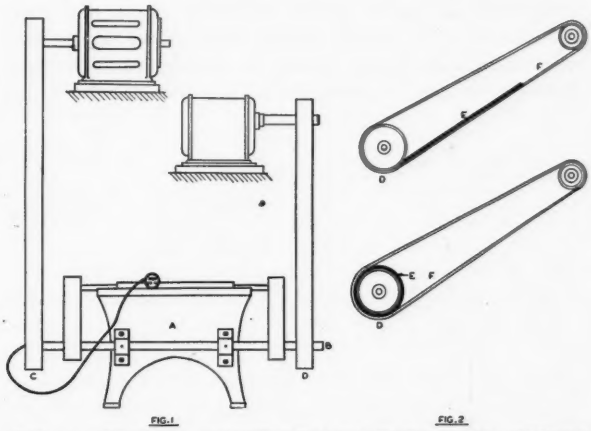


FIG. 1. PLANER COUNTERSHAFT WITH TWO MOTORS BELTED TO IT

FIG. 2. APPLYING FELT LAGGING TO A PULLEY

felt was needed and was applied on top of the first, with subsequent testing of speeds.

Speed testing with a revolution counter was a bit slow and tedious as well as inconsistent in results and, at this point, the foreman said naughty words about them. The millwright wished he had a tachometer, then became ingenious and took the speedometer off his trusty Ford. This was connected to the end of the countershaft as in Fig. 1 and the head set on the planer frame. Connection to the shaft was made by sticking the end of the flexible speedometer drive into a block of wood and fastening that to the end of shaft B. Motors could now be started alternately and comparative readings of shaft speed made instantly and accurately. Only comparative readings were needed as actual speed was known to be nearly enough right.

Another bit of felt was added, but proved too much so a piece was cut off and the shaft then ran at the same speed, whichever motor drove it.

With both motors pulling, the planer easily handled boards to the full width of its cutters and the drive has run for months with no trouble.

Probably the motors varied somewhat in their division of work at various loads but this was no matter so long as between them they pulled the load.

Sand Blast Found Effective in Removing Soot

WHILE a sand blast for cleaning soot from the tubes of horizontal return tubular boilers is not a new idea, it is so effective that I should think it would be used more than it is. In our plant the arrangement and location of equipment is such that we cannot use a flue brush

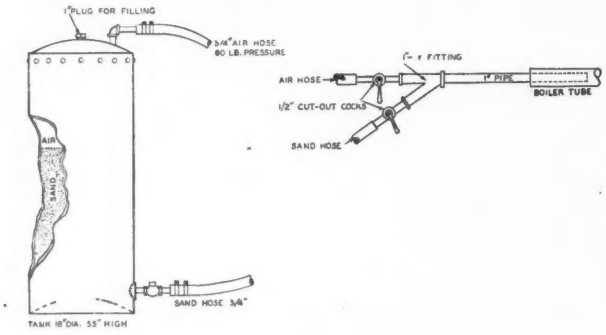


DIAGRAM OF EQUIPMENT USED FOR SAND BLASTING SOOT FROM FIRE TUBES OF BOILERS

or scraper, so I made up the outfit shown diagrammatically in the sketch.

By using this sand blasting equipment twice a month, we get excellent results, leaving our tubes as clean as a gun barrel. The flow of sand as well as air is under control at all times and, as far as we are able to detect, the tubes show no signs of being pitted or otherwise injured after using the outfit for over a year.

Care must be taken when operating the blast to shut off the sand flow when moving from tube to tube, otherwise the operator is quite likely to get a blast in the face or sand in his eyes. The precaution of wearing goggles, however, should always be taken when using a sand blast.

Our tank is made of 7/8-in. boiler plate and is safe for air pressures up to 100 lb.

Mechanicville, N. Y. R. S. LEACH.

Repairing Ammonia Systems

IN MAKING REPAIRS to ammonia systems, we are told by the manufacturers of refrigerating machinery to pump that part of the system down in which repairs are to be made but I have never been able to pump any system down so I could work without a gas mask. In case no mask is available, after pumping down all I can by the usual method in a reasonable length of time, I pump to the atmosphere the same as I would to get all the air out of the system but I open the valve I am using as the suction valve on the compressor just wide enough to create a slight suction in the opening on which I am working. In this way, the ammonia gas goes out through the machine to the atmosphere instead of coming out through the opening where I am working. After the job is finished, it is of course necessary to pump all air out before this part of the system is put back into operation.

In making acetylene welds in the system, if the workman is bothered with the ammonia gas the compressor may be used in the same way but no more suction than absolutely necessary should be used or the flame will be drawn into the opening and cooled to such an extent that the workman will not be able to make the weld.

In making repairs to ammonia pipes or valves of a condenser stand, always drain the water pipes in the stand or they may freeze and burst when pumping down.

In case a small leak develops in a weld or along the seam of a pipe, the best way to repair it is with an acetylene torch but if no torch or welder is available, the following method may be used as a temporary repair. If carefully made, it will hold up to 125 lb. After cleaning the pipe around the leak all the way around the pipe, cut a piece of heavy tin or light galvanized iron 6 or 8 in. long and wide enough to go all the way, excepting about one inch, around the pipe. Make three clamps, one for the middle and one for each end of the tin so they can be tightened with small bolts to hold the tin firmly against the pipe. Cut a piece of rubber sheet packing the same size as the tin. Pump the leaking pipe down to zero. Mix up enough litharge and glycerin to give the rubber packing a good coat all over one side and place this side of the packing next to and around the pipe so that leak is in the center of the packing. Put the tin over the packing around the pipe. Put on clamps and draw up evenly and tight. Pull the pressure in the leaky pipe down to just below zero and run for about an hour then operate the plant as usual. If carefully applied, the boot will hold until convenient to make permanent repair.

Where you don't have grease cones on your expan-

sion valve stems to keep them oiled, if you will close the king valve about every four months and oil the expansion valve stems by opening and closing three or four times, using a squirt can and the same oil you use in your ammonia compressors, your valves will always work easily. Your stem packing will last indefinitely and seldom leak.

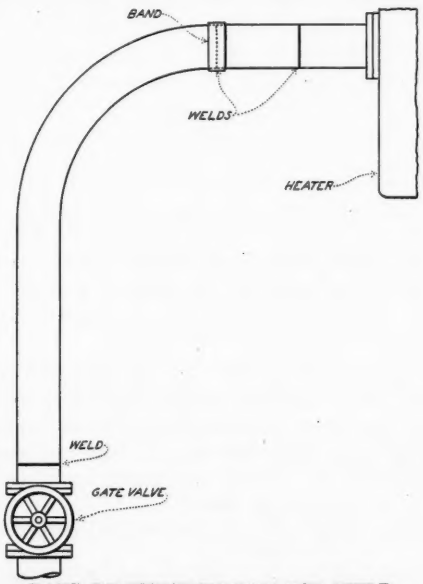
When any valve, excepting king or expansion valves, is changed from normal operating position, it is tagged by the man making the change, giving reason for change and stating whether valve is open or closed. A note is also left for all operators then off shift. When the valve is again in normal operating position, the tag is removed and operators are notified in writing.

In our plant we give no verbal orders. All orders are written out and the man going off shift stays until the man coming on has read all orders and understands them.

Chelan Falls, Wash. C. M. David.

Band Welded on Exhaust Pipe

Changes in the distribution of exhaust steam in a manufacturing plant called for the making of three welds in a 10-in. pipe containing a long-radius bend.



BAND RE-ENFORCEMENT FOR WELD

This pipe formed the branch from the main exhaust line to an open feedwater heater. The alteration consisted of shifting the gate valve indicated in the accompanying sketch from its original position between the two welds near the upper end of the pipe. This necessitated welding in a section at the upper end, also cutting out a section and the valve at the lower end. The oxy-acetylene welding process was used.

When exhaust steam at 6 lb. pressure was sent through, one of the upper welds opened, at the point where the curve in the pipe began. The engineer ascribed its failure to a bending stress induced by expansion.

The job was made good by filling the fracture with an iron cement, covering the weld with a sheet steel band as indicated and welding the ends of the band to the pipe. The band was formed by hammering a strip of mild steel about 5 in. wide and ⅛ in. thick into circular shape. This was clamped in place while it was being welded roundabout. The clamp was then removed and the abutting ends of the band welded together.

St. Louis, Mo. D. J. Altizer.

Quick Freezing for Pipe Repairs

Referring further to Quick Freezing for Pipe Repairs, in the June 1 issue, I feel that W. F. Schaphorst is right, with one slight reservation, the pipe must be free at both ends. Take any container, metal or glass filled with water free to move, and apply dry ice at any part and the water at point of application will be frozen solid without cracking or breaking the wall. Now, if a tight valve prevents the escape of the water forced away from the point of freezing as the ice expands, a break is sure, as the compressibility of water is zero for all practical purposes. As a practical test, a tightly closed 3-in. cylinder filled with water at 39 deg. F. may burst when either heated or cooled a few degrees. If cooled to freezing point (not frozen) or heated to 46 deg. F., the pressure exerted is about 800 lb. per linear inch. In freezing, this pressure is multiplied enormously, about 1200 times I believe.

I differ from Mr. Thorn that a pipe cannot be frozen if there is a leak. I have had half-inch pipes freeze solid while a fair stream was running, the action being the same as when a pipe or injector tube is stopped up with lime and magnesia salts. Another sure way of bursting pipes is to bury them unevenly so that they freeze in two places. A burst between the frozen points is inevitable.

Ice cans where distilled water is used, and which are not agitated do not bulge, because the thrust from the expanding ice is upward toward the open top, and the bottom is always exposed to the coldest brine. Yet an ice can that is allowed to thaw partially and then put back into the brine will be bulged like a watermelon.

Cleveland, O. L. R. Baker.

Exciters Reversing their Polarity

It is not unknown for alternator exciters to reverse their polarity due to a back flow from the alternator main field. This will occur whenever the current in the exciter armature dies down at a more rapid rate than it does in the exciter field. The discharge from the alternator field reverses the direction of current through the exciter armature and this often demagnetizes or reverses the field. These cases are most frequent where the exciter armature and field circuit are laminated and the alternator field core solid. Reversal is likely to occur when the main breaker comes out and the exciter field is quickly opened to prevent an undue voltage rise. The original polarity can be restored by running the set up, magnetizing the main field and then breaking the exciter circuit. Reversal has sometimes been achieved by putting field resistance in the exciter field at a rapid rate.

Herts, England. W. E. Warner.

Lagging on outside steam mains should always be protected by a water and weatherproof covering.

Questions and Answers

Steaming of Logs

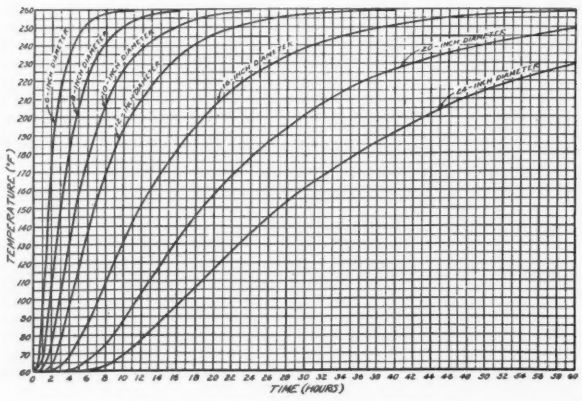
HAVE YOU any data on the preparation, that is steaming of logs, particularly in regard to steam pressure, length of time for steaming and effect of pressure of the steaming period? A. S.

A. From results of experimental work carried on at the Forest Products Laboratory, Madison, Wis., R. M. Wirka determined that with steam at 20 lb. gage (259 deg. F.), green unpeeled southern yellow pine could be heated throughout to 212 deg. F. in the time given by the equation

$$y = x^{1.5}$$

where

- y is the time necessary to heat the interior of the specimen to 212 deg. F.
- x is equal to the radial distance in inches.



TEMPERATURES AT CENTERS OF GREEN ROUND SOUTHERN PINE TIMBERS (INITIAL TEMP. 60 DEG. F.) WHEN STEAMED AT 260 DEG. F. FOR DIFFERENT PERIODS

To heat the interior to the temperature of the surrounding steam, that is 259 deg. F., the time is given by the equation

$$y = 2.4\,x^{1.59}$$

Moisture content can be decreased considerably by subjecting the log to the vacuum treatment following the steaming period. In the test reported, the average unit moisture loss varied from 5.1 lb. per cu. ft. with a 1-hr. vacuum treatment to 9.3 lb. per cu. ft. with a 6-hr. vacuum. The conclusion reached by the author was to the effect that the reduction of moisture can be gained with relatively short steam periods and long vacuum periods which will be nearly equal to or greater than that obtained in a long steam period followed by a 1-hr. vacuum treatment. Steaming for 4 hr. with a 1-hr. vacuum showed a moisture loss of 5.1 lb. per cu. ft. Density before treatment varied from 65 to 70 lb. per cu. ft.

Other tests were run at steam pressures of 20, 30 and 40 lb. No large difference existed in the rate of heating with the use of different steam pressures. Data indicate that when steaming for 8 hr. or less a pressure of 20 lb. is as desirable as one of 40 lb.

Further data from the same laboratory reported by J. D. MacLean in 1930 brought out the fact that steaming to excess may seriously impair the strength of timber. These latter investigations with green southern pine led to the preparation of the chart shown. This chart can be used for calculating temperatures at the center of green round southern pine timber of different sizes with steam at 260 deg. F., and initial log temperatures 60 deg. F.

For steam and log temperatures other than 260 and 60 deg. F., the temperature relation can be determined from the following equation:

$$T_w = T_s - \left(\frac{T_l - T_s}{60 - 260}\right)(260 - T_c)$$

where

- T_c is the log temperature taken from the chart for a given steaming period, deg. F.
- T_l is the initial temperature of the log, deg. F.
- T_s is the steam temperature; deg. F.
- T_w is the temperature desired at some definite steaming period with a steam temperature other than 260 deg. F.

For example, a 12-in. log (initial temp. 60 deg. F.) could be heated in 10 hr. to 193 deg. as shown by the chart. If the initial temperature, however, were 0 deg. F. (steam temperature 260 deg. F.) the temperature at the end of 10 hr. would be lower; in other words:

$$T_w = 260 - \left(\frac{0 - 260}{60 - 200}\right)(260 - 193) = 173 \text{ deg. F.}$$

If the initial temperature of the log had been 60 deg. F. the final temperature, after steaming 10 hr. at 320 deg. F., would be 233 deg. F. Thus it would seem that the initial temperature of the log is almost as important as the steam temperature. For winter conditions, steam temperature will have to be increased in order to reach the desired temperature in the same length of time.

For any assumed temperature conditions, the above equation reduces to comparatively simple form. For instance, with an initial temperature of 0 deg. F. and steam temperature of 275 deg. F.

$$T_w = 1.375\,T_c - 83$$

From experiments it has also been determined that a temperature of 150 deg. F. held for about 30 min. is reasonably sure to kill wood destroying fungi and effectively sterilize the timber. The chart will be found convenient for determining steaming periods that can be

depended upon to sterilize timber being treated. Some of the large sizes which could be used for piling, however, can not be heated to 150 deg. F. or over at the center without impractically long steaming periods.

EDITOR'S NOTE: Apparently few data are available on this important subject and engineers connected with wood treating plants, particularly for veneer cutting purposes, can contribute to the advancement of the art by sending in data regarding practice at their plants.

Centrifugal Pump Operation

Is IT POSSIBLE to figure the pressure developed by a centrifugal pump with 20-in. diameter impeller, running at 1200 r.p.m.? B. S. C.

A. Without testing pump or knowing the characteristic of the impeller, it is impossible to predict the performance of a centrifugal pump because the designer can make the head-capacity characteristic vary over wide limits to meet the desired requirements.

It is possible, however, to approximate the shut off head or head of impending delivery; that is, the head or pressure which will be developed when the discharge valve is completely closed. For this purpose, the pump operation is considered as a forced vortex. The head which will be developed is

$$h = u^2 \div 2G$$

where

h = head in feet

u = peripheral velocity of impeller in ft. per sec.

G = 32.2

In this case, the diameter of the impeller is 20 in. and the circumference or $20 \times 3.1416 \div 12 = 5.236$ ft. Running at 1200 r.p.m. or $1200 \div 60 = 20$ rev. per sec., the peripheral speed of the impeller would be $20 \times 5.236 = 104.72$ ft. per sec. The head, therefore, as above, would be $(104.72 \times 104.72) \div (2 \times 32.2) = 170.28$ ft. Water pressure developed by a head of 170.28 ft. would be $170.28 \div 2.31$ or 73.71 lb.

Although the ideal head of impending delivery can be figured as shown above, various pumps give values above and below that calculated. This may be accounted for in a number of ways of which probably the most important is the small amount of water short-circuiting by wearing rings, gland water leakage and the fact that actual conditions in the pump do not agree with the assumed theory.

Allowable Boiler Pressures

How DO YOU figure the allowable pressure for the water leg of a Manning boiler? W. H.

A. Maximum allowable working pressures for curved surfaces subject to internal pressure can be obtained by two methods as specified in paragraph P-212 of the A. S. M. E. Boiler Construction Code. The minimum value obtained from these two methods shall be used as the maximum allowable working pressure of that part of the boiler.

First Method. The maximum allowable working pressure (P_1) shall be computed without allowing for the holding power of the stays, due allowance being made for the weakening effect of the holes, for the stays or riveted longitudinal joint or other construction. To this pressure shall be added the pressure (P_2) secured by the formula for braced and stayed surfaces given in Par. P-199 using 70 for the value of C.

Second Method. The maximum allowable working pressure (P_1) shall be computed as before and to this pressure shall be added the pressure (P_3) corresponding to the strength of the stays or brace for the stresses given in Table P-7, each stay or brace being assumed to resist the steam pressure acting on the full area of the external surface supported by it.

Maximum allowable working pressure mentioned in the first part of these two methods as given in P-180 can be found from:

$$P_1 = \frac{TS \times t \times E}{R \times FS} \qquad (1)$$

P_1 = maximum allowable working pressure, lbs. per sq. in.
TS = ultimate tensile strength stamped on shell plates (as provided for in the Specifications for Steel Boiler Plate), lb. per sq. in.
t = minimum thickness of shell plates in weakest course, inches.
E = efficiency of longitudinal joint or of ligaments between tube holes (whichever is the least).
R = inside radius of the weakest course of the shell or drum, in.; provided the thickness of the shell does not exceed 10 per cent of the radius. If the thickness is over 10 per cent of the radius, the outer radius shall be used for R.
FS = factor of safety, or the ratio of the ultimate strength of the material to the allowable stress. For new constructions FS in the above formula = 5.

The formula in paragraph P-199 mentioned in the first method for calculating P_2 is

$$P_2 = C \times \frac{T^2}{p^2} \qquad (2)$$

where

P_2 = maximum allowable working pressure lb. per sq. in.
T = thickness in plate in sixteenths of an inch.
p = maximum pitch measured between straight lines passing through the centers of the staybolts in the different rows, which lines may be horizontal, vertical or inclined, inches.
C = 70.

Table P-7 mentioned in the second method of calculation to give the pressure P_3 is

Description of staybolts and stays or braces	Stresses, lb. per sq. in. For lengths between supports not exceeding 120 diameters[1]	For lengths between supports exceeding 120 diameters[1]
a Unwelded or flexible staybolts less than twenty diameters[1] long, screwed through plates with ends riveted over	7,500	.....
b Hollow steel staybolts less than twenty diameters[1] long, screwed through plates with ends riveted over	8,000	.....
c Unwelded stays or braces and unwelded portions of welded stays or braces	9,500	8,500
d Steel through stays or braces exceeding 1½ in. diameter[1]	10,400	9,000
e Welded portions of stays or braces	6,000	6,000

[1]Diameters taken at body of stay or brace

Pressure allowance for staybolts can be calculated as follows:

$$P_3 = \frac{SB \times s}{A} \qquad (3)$$

P_3 = Maximum allowable working pressure in lb. per sq. in.
SB = cross sectional area of staybolts.
s = staybolt stress from Table P-7 in lb. per sq. in.
A = Area of external surface supported by stay in sq. in.

To find the total allowable pressure of the water leg, it is necessary to calculate the pressures given by Eqs. 1, 2 and 3. The pressure P_1 from Eq. 1 is added to the pressure P_2 from Eq. 2 to give the answer by the first method and the pressure P_1 from Eq. 1 is added to the pressure P_3 from Eq. 3, for the answer by the second method. The minimum of these two sums gives the maximum allowable working pressure for the water leg of the boiler. This may or may not be the maximum allowable working stress of the entire boiler, however, as some other part of the shell may be weaker and the weakest section of the entire boiler determines the allowable working pressure.

Editorial Comment

Power Rates

General rate schedules of the public utilities have been severely criticized as being unduly complicated, and the justice of many of these criticisms is evidenced by the strenuous efforts being made by the utilities to simplify and standardize these schedules. In addition to external criticism, internal pressure has been brought to bear for the past two or three years, primarily as a result of long distance gas lines. These lines, owned in many cases by the same interests that control electric utilities, sometimes cross 10 or 15 power districts and must purchase power for their compressor stations under as many different contracts. Virtually they have been hoist by their own petard.

Rate determination is not simple, however, and there are many factors such as demand load conditions and power factor which must be taken into consideration. The matter of demand and load distribution influence is explained by the Rate Research Committee of the N.E.L.A., primarily in connection with hot water heating, although the fundamental reasoning applies equally well to other types of loads.

There are two general groups or classes of electric hot water heating systems. The first has an unlimited supply of electric energy similar to that enjoyed by other electric service and calls for the installation of a relatively small tank with a large heating element; the second, requires a large storage tank, in some cases as much as 100 gal. with low capacity heating elements, a time switch and relay control. Energy is consumed during the night or other light load hours and may be supplied at relatively low costs. In some instances, the second system may be modified by the use of a booster unit for occasional unrestricted operation, thus making it possible to reduce the size of the storage tank.

At one extreme is a customer with a relatively small investment in heating equipment, imposing a high demand on the utility at the time of the station or distribution peak and using the utility investment comparatively few hours each year. The other extreme is a customer with a large heating equipment investment imposing a lower demand on the utility during an off-peak period and operating in such a manner as to increase the system load factor.

Obviously the customers are entitled to different rates and a substantial inducement in the form of low energy charge should be offered to the off-peak, high-load-factor customer. This reasoning applies equally well to other types of loads and is a factor which should be taken into consideration by the industrial engineer putting in new equipment and making new equipment arrangements. In some industries, equipment for limiting the power demand is used and serves effectively to decrease the demand and even up the power load. Correction of low power factor is too well known to need further emphasis. Intelligent organization of these three points; the use of off-peak power, reducing the demand and increasing the power factor will do much to reduce the power bills of companies purchasing electric power.

X-Ray Examination

In spite of the objections from many quarters and the arguments advanced to show that the logical application of the X-ray in the metallurgical field is to perfect welding and casting technique, its use as a routine examination of the finished product meets the popular demand for assurance that important pieces of equipment are reliable. This examination seldom adds an appreciable amount to the cost of the product but adds a great deal to the peace of mind of the user as it relieves him of the necessity for placing absolute trust in the ability of an unknown foundryman or welder.

X-ray methods of inspection are well known and apparently will become a prescribed practice in the Code for Welded Boiler Drums, at least for a number of years, until they have been proved thoroughly reliable in practice. The action of the Navy in specifying X-ray examination of the welded drums which they are using should be followed in stationary practice.

There is no doubt about the practical development of commercial methods. The German railways are now using the X-ray machine in their shops as an everyday tool of inspection for locating concealed imperfections. After careful examination and investigation, a domestic company specializing in aluminum found that X-ray examination of material in its plant cost about $2 per sq. ft. of film and that a piece of aluminum 16 in. square can be X-rayed in a few minutes with precision and accuracy. At least one manufacturer of welded vessels finds it highly successful, practical and economical.

An interesting example of the industrial application is at the plant where autogyro planes are being constructed. Castings for the main support of the tripod arrangement which carries the revolving autogyro are subjected to severe strain and X-ray examinations of these castings have shown that external appearances may be quite misleading. The use of the X-ray extends the examination below the surface. Its use at any cost is justified by the fact that so far everyone of these vital castings passed by the X-ray test has functioned perfectly.

Electrically Grown Vegetables

For some years the utilities have been vitally interested in rural electrification, yet they have not fully appreciated the extent to which power may be used in the cultivation of flowers and vegetables. At the Missouri State School of Agriculture, an underground heating cable has been developed and applied commercially in a number of cases. The Union Electric Co. reports that some 80 electrically-heated hotbeds are now in use in St. Louis County with expectations of at least 300 by Spring.

Nichrome wire cable is insulated with asbestos and sheathed with lead. It is buried in the soil, giving close control of temperature and does not carry disease into the bed or emit fumes. Elements may be installed so that various sections may be heated to different temperatures.

Unquestionably this development has passed the experimental stage and blossomed into commercial usefulness practically overnight. Possibilities of the scheme as a load builder, particularly for the night valleys are good. This is but further evidence that the application of electricity has still great opportunity for development.

Off Duty

Several weeks ago Dr. Albert A. Michelson died. Ordinarily when a scientist dies, the event creates little attention outside of the scientific world; if the newspapers regard it at all, a brief paragraph or two in an obscure corner of the paper is about all that can be expected. After all, in the mind of the public, the average scientist is regarded more as a queer animal—interesting, of course, but not of any considerable importance. Dr. Michelson, however, was an exception, he was known better than most scientists and his death was of sufficient importance to command front page headlines. It was not to be expected, of course, that these headlines were quite as large or as numerous as would have been the case had say Mr. Alphonse Capone, DBL.,[1] died, but it was gratifying to note that Dr. Michelson's death was accorded front page attention.

A few days ago, Dr. Michelson's will was probated and it was disclosed that he left an estate totalling approximately $35,000. Now $35,000 in this modern world is not a great deal of money; indeed it is no greater than that accumulated by many elevator operators or truck drivers or janitors.

Of course, it may be that Dr. Michelson was a poor manager with respect to money matters, that he invested it unwisely or that he squandered it, and for these reasons left comparatively little, but we do not think so. We incline to the opinion that Dr. Michelson was more interested in his science than he was in the accumulation of wealth—that the development of a method for determining the absolute velocity of light meant more to him than the development of a fat bank account. In this it is not our desire to imply that Dr. Michelson scorned money—he probably understood the value of money as well as the next man but he did not make it a ruling force in his life. As a means to an end, yes—if someone offered him a million dollars with which to build a pipe line in which to measure the speed of a beam of light, his delight probably would have been unbounded, but a million dollars as such, not translated into scientific achievement would have meant little in his life.

After all, the "goods" which Albert Michelson accumulated in his 78 years of existence on this planet and which he willed to the world when he died, have a value far beyond anything which can be expressed in terms of mere money. In his development of methods in optics, in his contributions to astrophysics, and in his laying of the cornerstone, so to speak, of the Einstein theory, Michelson gave to the world something which it did not possess before.

To the general public Michelson was known primarily as the "man who measured the speed of light." The significance of this is only vaguely understood, but somehow it is accepted that measuring the speed of light is important and so Michelson was honored. What is not so generally known, however, is his work relating to the theory of relativity; that it was the result of an experiment which Dr. Michelson conducted together with Professor Morley, at the Case School of Applied Science in Cleveland, which led Einstein to formulate his famous theory.

This experiment had for its object the demonstration of the earth's absolute motion through the ether. Years before Maxwell in his electromagnetic theory of light had pointed out that this could be done by measuring the difference in time taken by a ray of light in traveling a certain distance, first in the direction of the earth's motion through space and second, in a direction across the line of the earth's motion. In principle this was simple, but as Maxwell pointed out it would involve an accuracy of measurement far greater than anything man was capable of, hence it was impractical.

Maxwell, however, could not foresee a Michelson, for by 1893 this young Annapolis graduate had developed his famous interferometer; a device so ingenious and so marvelously accurate that it could measure distances of less than a wave length of light, well within the limits of accuracy imposed by Maxwell's problem.

With this instrument and with a delicacy of technique that commanded the admiration of the scientific world, Michelson and Morley set out to measure the earth's absolute velocity through space. With infinite care and patience they conducted the experiment; all conditions were satisfied and they knew that they could easily have observed and measured the effect sought for, but to the astonishment of scientists the world over, they found no motion to speak of.

This remarkable fact—that there was only a negligible effect when all theory demanded a positive effect, was the clue which, later, led Einstein to formulate his theory of relativity. So indirectly perhaps, and without in any way disparaging Einstein's own brilliant role in formulating this revolutionary concept, the world owes to Michelson's interferometer credit for the theory of relativity.

Thus it seems that Albert Michelson's "estate" was considerably more than the newspapers stated. The $35,000 to which they referred was merely an incident necessary to his existence and was no more representative of his value to the world and humanity than are Mr. Capone's reputed several millions.

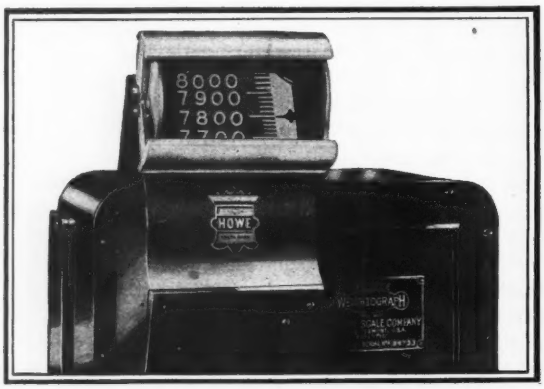
Some men build great fortunes and with these fortunes often do things of great value to the world. The great commercial enterprises which they build live and are of value long after the builders have ceased to exist. Other men, like Albert Michelson build fortunes of knowledge—knowledge often intangible in its value, but with which they endow the world for all time. Railroads, great factories, vast commercial enterprises may vanish from the face of the earth but the laws of a Newton or an Einstein or the principle of an interferometer will live as long as there are human minds to grasp them or volumes in which to record them. This is the kind of heritage which Michelson left to the world when he died. Truly, he was deserving of front page headlines.

[1]Doctor of bootlegging.

Power Plant Engineering Developments and News

Weightograph for Beam Scales

HOWE WEIGHTOGRAPH shown here is designed to be attachable to any built-in type of beam scale from 1000 lb. upward. Dial scales are also convertible to Weightograph operation, it is stated, by merely removing the dial head, the remainder of scale being retained. The Weightograph is an automatic weighing



NEW HOWE WEIGHTOGRAPH

instrument that permits present scale equipment to be continued and to enjoy the benefits embodied in the Weightograph, says its manufacturer, The Howe Scale Co. of Rutland, Vermont.

When attached to a beam scale (which of course has previously been operated manually by manipulation of the beam poises) the Weightograph provides automatic operation.

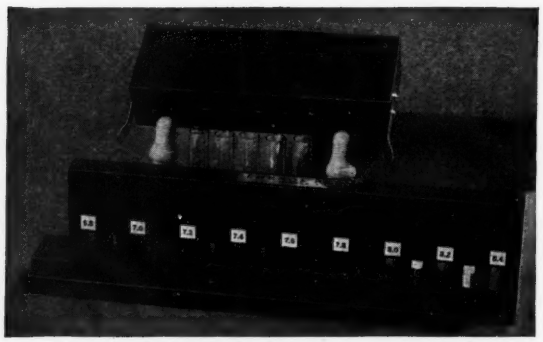
It is not to be understood by this that the Weightograph by its installation upon old scales, makes new ones out of old. It indicates exact performance of scale; no more, no less. The Weightograph magnifies the movement of the weighbeam by means of a precision chart or negative. Thus it employs optical magnification instead of mechanical multiplication. Advantages claimed for it are: accurate and instant balance, illuminated figures, absence of parallax, greater capacity or sensibility, reliability and durability.

New pH Equipment

AS A RESULT of long and varied experience with pH control equipment and methods, W. A. Taylor & Co., 872 Linden Ave., Baltimore, Md., has developed the new Slide Comparator, an instrument unique in design and construction. Being molded from Bakelite, it combines the maximum of durability, precision, convenience and simplicity. The Slide Comparator consists of two principal parts, the slide and the base. The slide is a Bakelite case 10 in. long, 2¾ in. high and ⅝ in. thick. It contains 17 vertical holes and 17 horizontal slots which pass through the exact centers of the holes. In these holes are placed the nine color standards for any given indicator and eight ampoules of distilled water. All these ampoules are held in place by a lid which is screwed on the top of the slide.

The base consists of two parts. The lower part contains a slot in which the slide may be moved back and forth, two holes containing vials of indicator solution, five holes containing test tubes, and a closed compartment for a ground glass plate. Vertical slots run through the three central holes in the base holding the test tubes, these slots corresponding exactly with any three of the slots in the slide. The ground glass is contained in a closed compartment directly behind the three slots in the base. The upper part of the base serves as a cover for the vials and test tubes when the set is not in use. It is fastened to the lower part by means of spring catches.

In making pH determinations, the top is removed from the base, three of the test tubes are filled to the



SLIDE COMPARATOR OF THE W. A. TAYLOR & CO. FOR pH DETERMINATIONS

mark (5 cc.) with the sample to be tested and placed in the three holes back of the slots in the base. To the central tube 0.5 cc. of the indicator solution is added by means of the pipette and nipple and the contents are thoroughly mixed. The slide containing the color standards is now placed in position on the base and, holding the instrument toward a window or other source of daylight, the slide is moved back and forth in front of the test samples until a color match is obtained. The pH is then read off directly from the values on the front of the slide.

Since the color standards are enclosed in a Bakelite case, there are no loose standards to be inserted and removed in making pH determinations. Thus all chance of loss or breakage from handling individual standards is eliminated. All color standards and test tubes are 11.5 mm. outside diameter. This small equipment makes the set small, compact and readily portable. Of far greater practical importance, however, is the fact that the resulting thinness of layer of material being tested enables one to make accurate determinations on far more highly colored and turbid materials, without dilution, than is possible with larger tubes. The fact that determinations are made simply by sliding the color standards in front of the test sample until a color match is obtained makes the operation of the set extremely simple so that it is possible to teach a workman to use the set accurately with a few minutes' instruction. Slide Comparators are supplied to cover the pH range 0.2 to 13.6. Each comparator covers a range of 1.6 pH units, the standards being in intervals of 0.2 pH. To meet the need of those workers who require a portable set covering a wide pH range, the Long Range Slide Comparator was designed. This set is made in seven models (T-3 to T-9) to cover the range of any 3 to 9 indicators respectively between the limits of pH 0.2 and 13.6, the number after T indicating the number of indicators included in the set. The Model T-9 can be made to cover the range pH 0.2 to 12.6 or pH 1.2 to 13.6.

Each Long Range Slide Comparator contains one complete Slide Comparator; two to eight extra color standard slides; vials of the corresponding indicator solutions, with pipettes and nipples; and a supply of 5 cc. test tubes. This equipment is contained in a portable case 11 in. long, 9½ in. wide and 4½ in. high.

Unit Cooler and Liquid Level Controller

GRINNELL UNIT COOLER, recently placed on the market, is designed for use with direct expansion ammonia, brine or other refrigerants, for a great many types of refrigerating work. It is designed to give quick cooling, positive air circulation, flexibility, savings in erection, maintenance, weight and power costs.

Tubes are seamless steel, with radiating fins, the whole being rust-proofed. A fully-enclosed ball bearing type motor drives an aluminum blade fan to force air over the cooling coils. Louvers are adjustable to direct the air discharge. Each unit is tested to 150 lb. air pressure under water before it leaves the factory. The Unit Cooler under average conditions with direct expansion ammonia develops about one ton capacity.

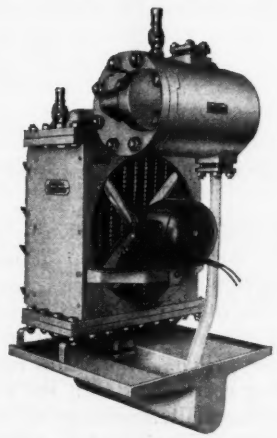


FIG. 1. GENERAL VIEW OF UNIT COOLER

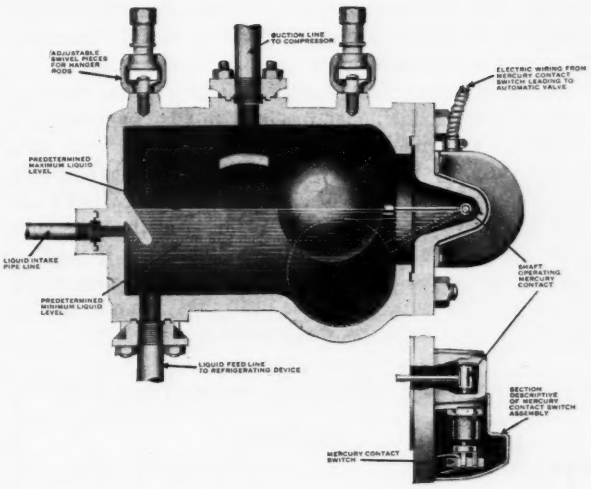

ADJUSTABLE SWIVEL PIECES FOR HANGER RODS
SUCTION LINE TO COMPRESSOR
ELECTRIC WIRING FROM MERCURY CONTACT SWITCH LEADING TO AUTOMATIC VALVE
PREDETERMINED MAXIMUM LIQUID LEVEL
LIQUID INTAKE PIPE LINE
SHAFT OPERATING MERCURY CONTACT
PREDETERMINED MINIMUM LIQUID LEVEL
LIQUID FEED LINE TO REFRIGERATING DEVICE
SECTION DESCRIPTIVE OF MERCURY CONTACT SWITCH ASSEMBLY
MERCURY CONTACT SWITCH

FIG. 2. DETAILS OF LIQUID LEVEL CONTROLLER

One of its features is the liquid level controller for holding the refrigerant at any predetermined level in the coils. Its construction is shown in Fig. 2. After the desired liquid level is determined, the control is located at the proper height. A steel ball float riding in the liquid operates the control, actuating a mercury contact switch that in turn opens and closes a solenoid valve in the liquid supply line, allowing the liquid refrigerant to flow into the level control chamber. When the maximum level is restored, the electrical contact is broken, allowing the solenoid valve to close. The supply line is opened only when the valve is energized by electric current but remains closed in case of power failure, thus providing a safety feature.

While the liquid level control is shown here as applied to the unit cooler, it is stated that it can be applied wherever liquid level is to be controlled on other equipment. Both unit cooler and liquid level controller are made by Grinnell Co., Inc., Providence, R. I.

New Firebrick Announced by the B. & W. Co.

ANNOUNCEMENT has recently been made by the Babcock & Wilcox Co. of a new firebrick known as B. & W. No. 80 Insulating Firebrick. Although this material has been previously made experimentally, no practical method of manufacturing it in brick size has been developed until recently, but it is now being produced on a commercial scale.

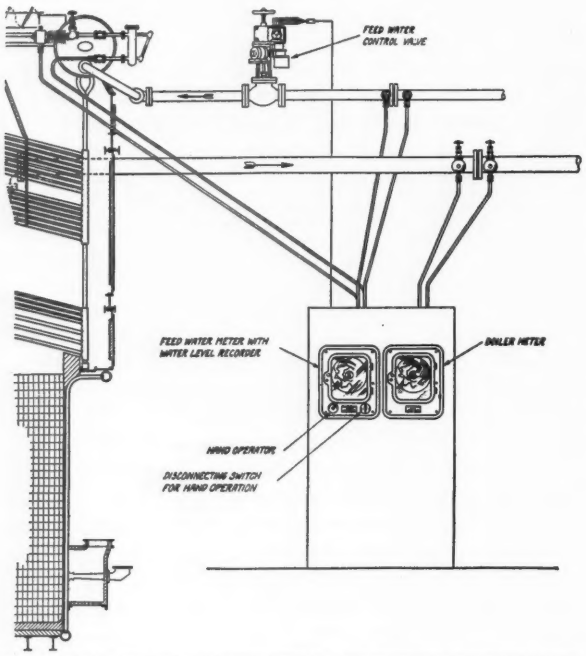
This material is not only an insulator but a high quality firebrick as well. The insulating properties compare very favorably with the best grades on the market. The thermal conductivity in B.t.u. per sq. in. per deg. F. per hr. varies from 1.3 at 400 deg. mean temperature to 3.0 at a mean temperature of 2000 deg. F. As a building material under load test of 6 lb. per

sq. in., the deformation curve crosses the zero line at 2400 deg. F. increasing to 3.5 per cent at 2650 deg. and to 10 per cent at 2715 deg.

The manufacturer reports that this brick may be used without a facing of firebrick on the furnace side, exposed to furnace temperatures and gases and protected only by a coating of No. 80 high temperature patching cement. The brick is suitable for lining oil and gas fired furnaces, electric furnaces of the resistance type and for coal fired equipment wherever it may be used in protected wall areas not exposed to mechanical abrasion and slag action. The bricks may be cut, drilled or shaped by ordinary woodworking tools.

Three-Element Feedwater Control

TO PROVIDE adequate feedwater control for modern steam generating units in which changes of rating are rapid, the Bailey three-element feedwater control


FEED WATER CONTROL VALVE
FEED WATER METER WITH WATER LEVEL RECORDER
BOILER METER
HAND OPERATOR
DISCONNECTING SWITCH FOR HAND OPERATION

INSTALLATION OF BAILEY THREE-ELEMENT FEEDWATER CONTROL

has recently been developed. This control may be designed to carry a higher water level at a higher rating and a lower water level at the lower rating in order to offset the effect of swell and shrinkage of water volume which may occur within the boiler unit during rating changes.

To secure the best results from regenerative and reheating cycles, as well as to secure the highest combustion efficiency, the rate of feedwater flow to the boiler, it is stated, must follow closely the rate of steam flow from the boiler. If these two quantities do not closely match each other, it is claimed, turbine efficiency is lowered because of varying quantities of steam required for bleeder heaters at constant turbine load.

The three elements from which this control is operated are steam flow, water flow and water level. This arrangement is intended to provide for a water level which increases with rating to prevent water shrinkage from draining the storage space in the boiler drum in case of a sudden load drop. An installation of this type is shown diagrammatically.

Linkage for coördinating the three factors to control the rate of feedwater flow in accordance with rate of steam flow and boiler water level is also contained in these meters.

The Bailey system of long distance transmission incorporating the use of Selsyn motors is used to transmit the demand for more or less feedwater flow as indicated by the meter to the regulating valve in the feedwater line.

The Bailey three-element control regulating valve designed for 1600 lb. pressure service is also shown. This valve is hydraulically operated by oil pressure which is in turn produced by the electric motor. The feedwater requirement as transmitted by Selsyn motors from the meters, operates a small hydraulic pilot valve which in turn operates the regulating valve by a power cylinder. This power cylinder is directly behind the motor and under the casing which houses the receiving Selsyn motor and pilot valve. A full-balanced tight-seating valve construction, similar to that used in the standard Bailey feedwater regulator, is used to regulate the flow of feedwater through the valve body. This valve construction is designed to be easily removable and to give a straight-line flow characteristic. The three-element control is a recent product of Bailey Meter Co. of Cleveland, Ohio.

Boiler Blowoff Hydrometer

EVERYDAY BOILER PLANT practice has shown that for a given boiler design and set of boiler operating conditions there is usually a maximum saline concentration beyond which steam of good quality will not be obtained. It is customary to use a hydrometer

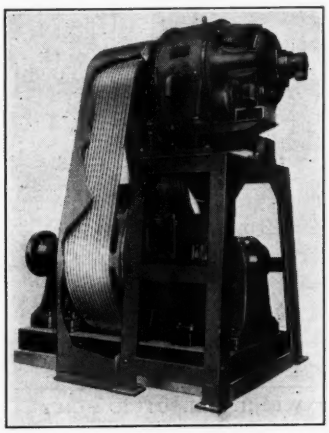
BLOWOFF HYDROMETER WITH TEMPERATURE CORRECTION DEVICE

to determine this saline concentration or density (which is a measure of the concentration of dissolved salts). But the hydrometer reading varies according to the temperature of the liquid; a change of only 5 deg. F. is equivalent to a change in concentration of about 100 grains of salts per gallon. This means reading temperatures and making corrections with the aid of tables or perhaps waiting for the temperature of the boiler saline to reach the exact point for which the hydrometer is calibrated.

To overcome these difficulties, the Permutit boiler blowoff hydrometer has been developed. This hydrometer is designed to make it possible reading of temperature corrections directly in terms of density. An integral thermometer is placed in the bulb of the instrument to make it possible for the operator to make the correction readily and instantaneously. This hydrometer is a recent product of The Permutit Co. of New York.

Adjustable Speed Control

BECAUSE of its high operating efficiency, the Rossman System of adjustable speed control, which is built by the Allis-Chalmers Mfg. Co., Milwaukee, Wis., is meeting with success for operating power plant auxiliaries and the manufacturer feels that it will have a wide field of application in varied industries involving the use of other machinery requiring a variable speed drive. This system involves a method of controlling the speed of a given alternating-current drive machine over a wide speed range and of accomplishing this with unusually high efficiency.



ROSSMAN VARIABLE SPEED DRIVE AS BUILT BY THE ALLIS-CHALMERS MFG. CO.

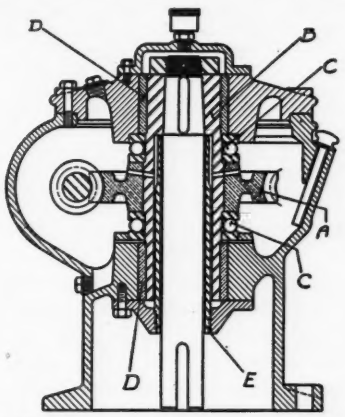
If the stator of a synchronous motor or an induction motor, instead of being mounted and held rigid on a base plate, is rotated in bearings of its own, then the rotor, which has a definite relationship of speed between itself and the stator, will always hold this same relationship whether the stator is rotated or held still. If the stator is rotated in the same direction as the rotor is running, then the speed of the rotor will be greater than its synchronous speed. If the stator is rotated in the opposite direction to that in which the rotor is running, then the speed of the rotor will be lower than its synchronous speed. If it were mechanically possible to rotate the stator at synchronous speed, then the speed of the rotor would be zero. The rotor speed is constant for any adjusted value and independent of the load.

The stator rotor of the main unit is mounted in bearings which are independent of the rotor bearings. The stator is mechanically connected to a d.c. machine either directly or through a Texrope Drive. Speed regulation is effected by means of a small motor-generator set, the armatures of the d.c. machines being electrically connected. The direction of rotation and speed of the d.c. machine is governed by holding its field voltage constant and varying the armature voltage through the motor-generator set. The Rossman System is used for both constant and variable torque drives.

Leak Proof Vertical Worm Reducer

AS A SOLUTION of the problem of positive elimination of oil leakage on slow speed shafts of vertical reducers, Foote Bros. Gear and Machine Co., Chicago, Ill., announces a new vertical leakproof Hygrade worm gear reducer line, designed for use in chemical, paint or food plants, wherever the slightest leakage of oil will contaminate and damage the product. The leakproof feature is incorporated in any of the standard vertical Hygrade units manufactured by this company, at a small additional cost.

The bronze worm gear ring A is pressed on a splined hollow steel center B and is held rigid on this center by two flat ball thrust bearings C. This complete arrangement is mounted on bronze bearings D and the hollow center is securely fastened to the vertical shaft at the uppermost part of the reducer, thus forming a cavity below this point for nearly four-fifths of the entire length of the shaft. In this space is placed a tube E, which is sealed and fastened to the lower part of the reducer from where it extends upward to a point well above the oil level. At the top the opening of the tube is covered by the steel center B. This arrangement, it is claimed, positively prevents any oil from leaking out and forms two chambers, one in which the worm gear operates and the other in which the vertical shaft rotates free from the contact of oil at all points.



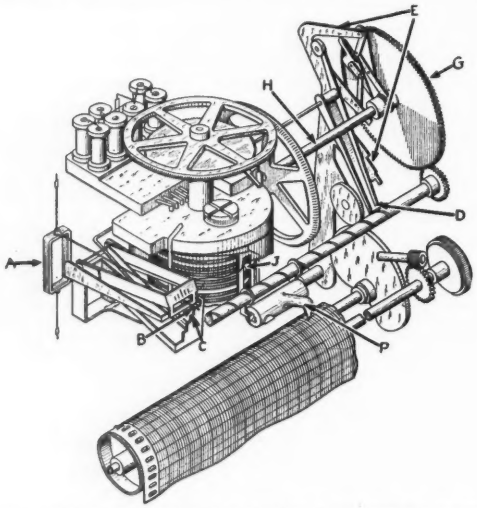
DETAILS OF NEW VERTICAL REDUCER SHOWING METHOD OF PREVENTING LEAKAGE

ELECTRIC MACHINERY MFG. CO., Minneapolis, Minn., announces that an arc-welded fabricated steel stator frame construction will now be used for all medium and slow speed E-M synchonous motors. A recent change from a two-piece cast-iron stator to a welded steel stator for small size motors completes the changeover to fabricated steel stator frames. This change makes uniform in appearance and general construction the entire line of E-M engine type and coupled pedestal type synchronous motors.

Potentiometer Pyrometer

NULL TYPE POTENTIOMETER PYROMETER to indicate, record and automatically control temperature with extreme precision is being placed on the market by the Brown Instrument Co., Philadelphia, Pa. The prime object in the development of this instrument was to produce an extremely accurate pyrommeter to meet the requirements in modern industrial practice and sufficiently rugged to withstand severe service conditions met in industry.

The Brown potentiometer pyrometer incorporates some 53 features new to potentiometer pyrometers, including a positive driving mechanism controlled by the galvanometer and exerting minimum force on the galvanometer pointer and a long 40-in. slide wire enclosed in glass; this wire can be immersed in oil where desired for protection from corrosive gases and vapors.



OPERATING PRINCIPLE OF BROWN POTENTIOMETER PYROMETER

Another improvement is an automatic compensator to correct the pen position for expansion and contraction of the chart paper with change in humidity of the atmosphere. The oblong holes in a strip chart are necessary to permit this expansion and contraction with change in humidity and this movement of the chart can cause an error of as much as 1 per cent of full scale value if not corrected for.

Automatic temperature control is obtained through mercury switches designed to handle up to 25 amp. directly without the use of relays. The case has been designed so that the instrument can be mounted on a wall, on a table, or either front-of-board or flush mounted on a panel board. These few examples of the new features of the Brown Potentiometer indicate the care that has been taken in the design of this new instrument for accurate measurements under severe service conditions.

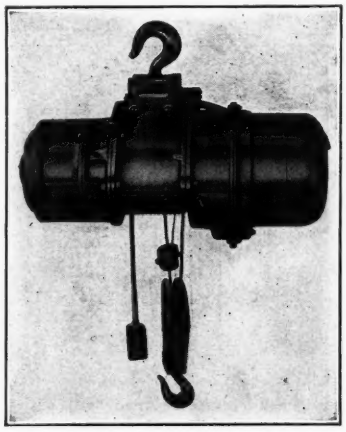
NATURAL GAS ranges from about 700 to 1200 B.t.u. per cu. ft. higher heating value.

WHEN SAMPLING oil from tank cars according to the A.S.T.M. method, the thief should take the sample from within at least ½ in. of the bottom. For drums the thief should reach within ⅛ in. of the bottom.

Type W Electric Hoist

WRIGHT TYPE W ELECTRIC HOIST, recently put on the market, is built for installations where high operating speeds, economical operation, and low-cost maintenance are first essentials. To obtain high speeds plus efficient operation, the motors are of a liberal size and designed especially for this type of hoist. Low-cost maintenance, extremely simple construction, and the use of the highest grades of materials such as alloy steel shafts, drop-forged, heat-treated gears and pinions, and Tru-Lay Preformed Cable, are features of design.

The hoists are designed for different types of suspensions. They are furnished with either push button or pendant rope control at the same price.



WRIGHT ELECTRIC HOIST

The motors and controls are fully enclosed—dustproof and weather-proof so that the hoists are suited for both indoor and outdoor installations. These hoists are a new product of Wright Manufacturing Co., Bridgeport, Conn.

HAROLD F. BROWNE, chairman of the organizing committee, states with regard to the Conference of Smaller Industries, to be held at Silver Bay on Lake George, N. Y., Aug. 10—15, by the National Industrial Conference Board, Inc.:

"It is intended to provide an opportunity for executives of smaller plants to meet and study jointly important industrial problems as they affect operation in the smaller units of industry. In the United States 193,562 manufacturing plants normally employ 500 or less laborers each, as compared with 2,747 establishments that employ more than 500."

Included in the program of sessions, which will be held morning and evening, leaving afternoons free for recreation, will be papers on problems of the small plant as to Economic and Social Progress, Wage and Price Movements, Planning and Budgeting; Motion Study, Research, Power Problems, Cost Determination; Personnel Relations, Stabilization of Industry, Safety, Sales Policy, Training Courses and Wage Incentives.

Further details can be had from Charles R. Towson, Executive Secretary, 347 Madison Ave., New York City.

Gift to the Engineering Foundation

PRESIDENT John V. N. Dorr, of the United Engineering Trustees, Inc., and Chairman H. Hobart Porter of The Engineering Foundation, have announced that Ambrose Swasey, founder of The Engineering Foundation, has just added $250,000 to his previous gifts, bringing their total to $750,000. In making this gift, Mr. Swasey said, "For many years past, and especially since 1914, I have thought that a great service to mankind might be rendered by the stimulation of research and development work in the engineering profession and have sought to further that end by assisting in establishing The Engineering Foundation, whose income would be available for such purposes.

"It has been my privilege on previous occasions to assist in the endowment of this Foundation and, having a high appreciation of the very practical and helpful results that have been already achieved, and believing that the broad and well-laid plans of the Foundation promise even greater service in the future, I now take great pleasure in making available to The Engineering Foundation, through United Engineering Trustees, Inc., an additional fund of $250,000 for the furtherance of research in science and engineering or for the advancement in any other manner of the profession of engineering and the good of mankind."

Mr. Swasey, born at Exeter, New Hampshire, nearly 85 yr. ago, is the surviving member of the firm of Warner & Swasey, of Cleveland, Ohio, famous for the building of great telescopes and instruments and machine tools of precision. The Engineering Foundation was founded in 1914 on the basis of his conception of research instrumentality for the profession of engineering and for broad services to mankind. It was established by the national societies of Civil, Mining and Metallurgical, Mechanical and Electrical Engineers.

News Notes

BALDWIN LOCOMOTIVE WORKS of Philadelphia, Pa., has purchased the subsidiary companies of Cramp-Morris Industrials, Incorporated, namely: I. P. Morris & De La Vergne, Inc., De La Vergne Engine Co., The Pelton Water Wheel Co., Cramp Brass and Iron Foundries Co., Federal Steel Foundry Co.

I. P. Morris & De La Vergne, Inc., De La Vergne Engine Co. and The Pelton Water Wheel Co. have become subsidiaries of the Baldwin-Southwark Corp., which in turn is one of the principal units of The Baldwin Locomotive Works. The Pelton Water Wheel Company will continue to operate as an independent unit with headquarters in San Francisco, California.

Cramp Brass and Iron Foundries Co. has become a subsidiary of The Baldwin Locomotive Works, while the assets and business of Federal Steel Foundry Company have been acquired by Standard Steel Works Co., of Burnham, Mifflin County, Penna., another Baldwin subsidiary.

Principal works and offices of The Baldwin Locomotive Works are at Eddystone, Pa., and the operations of the above mentioned subsidiaries, except The Pelton Water Wheel Co. and the Federal Steel Foundry Co., will be carried on at the Eddystone Works.

All mail and telegrams due for arrival on or after June 28, 1931, for the companies to be located at Eddystone, including the Atlantic Department of The Pelton Water Wheel Co., should be addressed to these companies at: Paschall Station Post Office, Philadelphia, Pa. Telephone (Philadelphia) Woodland 9161. A consolidated New York Office has been established at 120 Broadway, New York City.

Machinery operations of I. P. Morris & De La Vergne Inc., and the foundry operations of Cramp Brass and Iron Foundries Co. will in due course be moved from their present location in Philadelphia to the Baldwin Plant at Eddystone.

WM. POWELL CO. announces with profound sorrow the death of its friend and associate, Charles Cullen, in Latonia, Ky., on June 25, 1931. He will be remembered by those who attended the many conventions of the National Association of Power Engineers, at which he always had charge of the Powell exhibits and was socially prominent. He had been continuously associated with The Wm Powell Co. since 1891.

CEMENT GUN CONSTRUCTION CO. has moved its New York office to 1169-1171 Woolworth Building, New York.

E. A. THUMLERT has recently joined the sales organization of The Fairfield Engineering Co., Marion, Ohio. Mr. Thumlert was connected with the Beaumont Mfg. Co. for 16 yr. and for several years was its secretary and general manager. He was later connected with the Palmer Bee Co. of Detroit.

KIELEY & MUELLER, Inc., New York City annonuces the appointment of Engineering Sales Co., under the direction of H. E. Wheeler and H. J. Prebensen at 2831 South Park Way, Chicago, as its representative for Northern Illinois.

THE BEARDSLEY & PIPER CO., 2541 North Keeler Ave., Chicago, announces the acquisition of the services of Aubrey J. Grindle, pulverized fuel engineer, who has been placed in full, active charge of the newly organized Beardsley & Piper pulverized fuel department.

THE DAMPNEY CO. of Hyde Park, Boston, Mass., announces that William Richards has become associated with its Marine Department in New York. Mr. Richards was formerly Chief Engineer of the United States & Australasia Lines, also for merly attached to the Fuel Conservation Section of the United States Shipping Board, and recently Assistant Marine Superintendent of Lykes Brothers-Ripley S. S. Co. at Galveston, Texas.

PEERLESS HEATER CO., Boyertown, Pa., announces the appointment of Himelblau, Agazim & Co., 30 N. Dearborn Street, Chicago, Ill., as its new sales and service representative for the Chicago District in Northern Illinois and Western Indiana.

LUCIUS R. EASTMAN, president of the American Arbitration Association, 521 Fifth Ave., New York, announces the election of Ellis L. Phillips of New York City to the board of directors of the association. In addition to Mr. Phillips' wide New York interests in the public utilities field, he is at the head of public utility and power corporations in various parts of the country, being chairman of the Board of the Elmira Water Light and Railroad Co., Kings County Lighting Co., Rochester Central Power Corp. and Queens Borough Gas & Electric Co., among others. He is also president of the Western Utilities Corp. and Northport Water Works Co. and a Director of the Houston Gas & Fuel Co.

SQUARE D CO. of Texas, a subsidiary of the Square D Co., Detroit, Mich., recently opened its new factory at 3111 Polk Ave., Houston, Texas.

RALPH M. HOFFMAN, for 8 yr. manager of the Seattle office of the Pacific Division of Link-Belt Co., has been appointed vice president and sales manager of that division, with headquarters at San Francisco.

AFTER 30 YEARS of service with Link-Belt Co. and its subsidiaries, Harold H. Clark retires from his position of vice president and assistant secretary of the Pacific Division.

LUKENWELD, INC., division of Lukens Steel Co., Coatesville, Pa., has appointed W. R. McDonough & Co. as its representative in the Cleveland District. The company has also appointed the Dravo Doyle Co. as its representative in the Pittsburgh territory.

CONDIT ELECTRICAL MFG. CORP. announces a new indoor oil circuit breaker, known as the type DR-140, offering such features as all poles in one tank, totally enclosed mechanism, gasketed joints between tank and frame, oil and gas separator and expulsion type contacts. Some of the advantages of these features include small space requirements, quick clearing operation and freedom from oil throwing. It is furnished three-pole, electrically operated, for 600, 1200, 1600 and 2000 amp. at 15,000 v.; and 3000 amp. at 7500 v. It has an estimated interrupting capacity of 14,000 amp. at 15,000 v. It is also furnished manually operated in the lower ampere capacities.

GROUND HAS BEEN BROKEN, according to a recent announcement, for a new utility house and power plant at the Beth Israel Hospital in the Fenway, Boston, Mass. The structure is a gift of the life members of the auxiliary.

THE STRONG-SCOTT MFG. CO. of Minneapolis announces the appointment of Dravo-Doyle Co. as district representatives in Chicago (Marquette Bldg.) and in Cleveland (4800 Prospect Ave.) for sales and service of its equipment.

Books and Catalogs

ENGINE PERFORMANCE at High Compression Ratios by H. E. Zuck has been published as engineering research circular No. 6 by the Department of Engineering Research, University of Michigan, Ann Arbor, Mich., price, 50 cents. The tests reported in this circular were undertaken to secure quantitiative information on the effect on automobile engines of increase in compression ratio. The results of the test indicate that the maximum power available in internal combustion engines increases slowly with an increase in compression ratio even after detonation occurs. It continues to increase still more slowly, however, until severe detonation occurs with every explosion. At this point, any further increase in compression ratio results in a sharp drop in power. This point is not necessarily the point of auto ignition. Full advantage can be taken of the increased power made possible when using a non-knocking fuel by merely advancing the spark, it is stated. With a high compression engine equipped with an adequate spark control, a poor fuel may be burned as efficiently as in an engine of lower compression ratio.

LUMBER AND ITS USES by Royal S. Kellogg. Published by the Scientific Book Corp., 15 East 26th St., New York, N. Y.; 365 pages, 6 by 9 in., full flexible fabrikoid; price, $4.00.

Entirely reset and rewritten, the fourth edition of this book covers all phases of lumber utilization in a definite, direct and practical way. Of most value to our field are comprehensive chapters on the physical properties of wood, lumber grades and sizes, structural timbers, preservation methods, fire-resistance, paints and wood finishes. The book is well arranged with a very comprehensive 12 page index and contains a great deal of data not readily available elsewhere to the power plant and industrial field.

ENCO BAFFLE PART SHEET, a description of the special firebrick tile and the plastic material used for repairing all types of boiler baffles is the title of a new bulletin BP-31 just issued by the Engineer Co., 17 Battery Place, New York, N. Y.

PROPELLER TYPE FANS, made of pressed steel with welded parts to produce strong, light-weight construction, are described in a new catalog, No. 385, by B. F. Sturtevant Co., Hyde Park, Boston, Mass. Ball bearing motors drive these fans, which may be obtained either with or without wall mounting panel. The series of fans is made in sizes from 12 to 25 in.

SQUARE D COMPANY of Detroit, Milwaukee and Peru, Ind., announces the publication of a new bulletin dealing with Square D Dead Front Switchboards, which is of particular interest to architects, industrials, school officials, etc. It describes the two types of switchboards manufactured by the Square D Co.—dead front with open back and dead front with enclosed rear—and includes architects specifications and drawings.

DIAL TYPE THERMOMETERS are completely described and illustrated in a 32-page booklet just published by the Foxboro Co., Foxboro, Mass. Each type of instrument is described and data are given on dials, ranges, bulbs, tubing, gageboards and other details, with pictures of typical installations.

NI-RESIST, a special type of alloyed cast iron for improved resistance to many acid and alkaline solutions, its great ability to withstand elevated temperatures and unique electrical characteristics are described in detail in Bulletin No. 208, issued by The International Nickel Co., Inc., 67 Wall St., New York, N. Y.

NICHOLSON welded steel float, heat treated and non-collapsible, for steam traps, water columns, tanks, float valves, liquid level controls, and so on, is described and illustrated in bulletin No. 431 just issued by W. H. Nicholson & Co., Wilkes-Barre, Pa. This float is supplied in nickel, chromium or cadmium plated form.

IN A 20-page catalog recently issued by Walworth Co., Boston, Mass., the full line of iron and steel lubricated plug valves for a wide range of pressures and uses is fully described and illustrated.

L. H. GILMER CO., Philadelphia, Pa., has issued a new 84-page letter size V-belt catalog. It comprises two sections, the first devoted to theoretical and practical illustrations of V-belts themselves and their operation in multiple drives for various classes of service. The second or engineering section introduces new, simple and original formulas for all V-belt calculations, detailed tables of drives, from fractional to several hundred horsepower and a large chart for quickly determining center distances, belt lengths and useful data.

PUMPS FOR HANDLING liquids carrying solids in suspension are described in a catalog of Clogless Pumps, issued by the DeLaval Steam Turbine Co., Trenton, N. J. These pumps are characterized by horizontally split casings, either enclosed or open impeller, overhung upon a shaft resting in two ball bearings, one of the thrust type, capable of taking all unbalanced thrust, including the weight of the impeller.

WATER WORKS pumps progress since 1913 is illustrated in a leaflet issued by DeLaval Steam Turbine Co., Trenton, N. J., describing the equipment installed in 1913 and in 1929 at Ross station in Pittsburgh, Pa. The older unit was for 100,000,000 gal. per day at 106 lb. steam pressure and 56 ft. head. The newer ones were 100,000,000 and 50,000,000 gal. per day at 315 lb. steam with 200 deg. F. superheat against 57 ft. head.

SIXTH EDITION of the Standards of The Hydraulic Society has just been issued. It is an enlarged booklet of 96 pages showing numerous additions and changes. Among the new material added is an index; a list showing the different types of pumps made by the member companies; illustrations of the rotation of centrifugal pumps; new definitions and illustrations of thrust bearings; illustrations of correct and incorrect methods of connecting suction pipe to a centrifugal pump; a revision of recommendations of materials for pumping special liquids; a section on friction of paper stock in cast iron pipe, including nine pages of pulp friction curves. Price of the book is $1 and copies may be had from members or the Secretary, C. H. Rohrbach, The Hydraulic Society, 90 West St., New York.

CARE AND REPAIR of the House to keep it in perfect condition is the title of a booklet covering structure, roof, trim, heating, plumbing, lighting and other details, published by the Bureau of Standards. It can be obtained from the Supt. of Documents, Gov't. Printing office, Washington D. C., by enclosing 20 cents.

ELEVATING AND CONVEYING machinery is described and illustrated in a new 18-page bulletin published by Freeman-Riff Co., Terre Haute, Ind. This describes typical layouts of coal and ash handling machinery for various types of power plants and for various industrial materials.

NEW LINE of potentiometer pyrometers is described in Catalog 1101, a 48-page well illustrated book just issued by The Brown Instrument Co., Philadelphia, Pa. It contains a short introduction outlining the nature and field of the potentiometer principle as applied to pyrometry, shows how this principle is incorporated in the new Brown potentiometer pyrometer and follows this with a concise description of more than fifty features. The instrument is designed for broad application to industrial needs involving the measurement and control of temperatures, especially in the higher ranges.

TYPE T heavy duty Reliance motors for direct current are described in Bulletin No. 209, a 32-page, well-illustrated bulletin just issued by the Reliance Electric & Engineering Co., Ivanhoe Road, Cleveland, Ohio.

ELECTRICAL CONTROL equipment of all types is described in a new loose-leaf, letter-size bulletin issued by the Clark Controller Co., Cleveland, Ohio and Sundh Electric Co., Newark, N. J. This includes detailed data on float switches, a.c. automatic starters, remote control lighting switches, phase reversing and motor failure protection relays, magnetic and inverse time limit overload relays, and d.c. compound manual motor starters and similar equipment.

CHART for use in making rapid and accurate calculations of expansion loops made up of tube turns and straight lengths of pipe is included in a recent Bulletin No. 106 published by Tube Turns, Inc., Shelby St. and North Ave., Louisville, Ky.

HEAT EXCHANGERS, recent developments in theory, design and manufacture, with researches on transfer coefficients for oils and other fluids is the title of Bulletin No. 350, issued by Ross Heater & Mfg. Co., Inc., Buffalo, N. Y. It embodies a series of papers presented at a Heat Exchanger Conference of refinery and consulting engineers, covering Heat Transfer Equations, Tests, Theory of Heat Exchange, Thermo-dynamics of Heat Exchangers, Selection of Heat Exchanger, Design of Heat Exchanger. These papers were by members of the engineering staff of the company and embody the results of a long series of studies, tests, experiments and checks on the action in heat exchangers.

INSPECTION of internal boiler surfaces and what to look for after a period of regular operation are discussed in bulletin No. 1270, recently issued by the Dampney Co. of America, Hyde Park, Boston, Mass.

GAGE PROTECTION VIA THE CHAMPION METHOD, is the title of a new bulletin of Champion & Barber, Inc., 576 Subway Terminal Bldg., Los Angeles, Calif., which describes the Champion gage protector and the Champion Non-pulsator, the former to transmit line pressures to a gage by means of a secondary or bulb pressure, the latter to eliminate the effects of pulsation on the gages.